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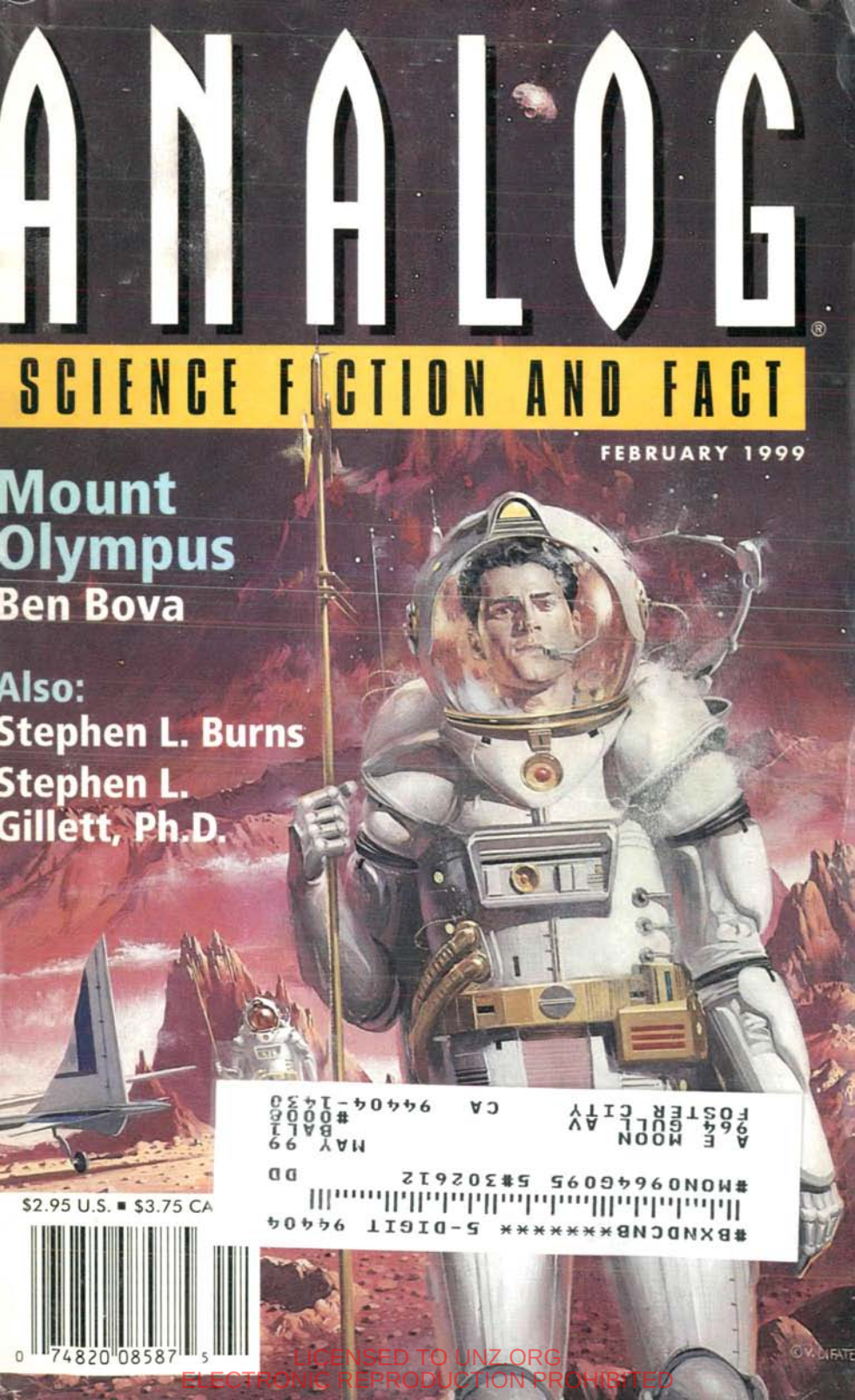

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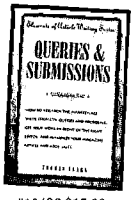

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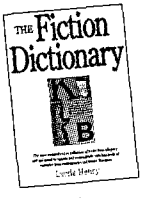

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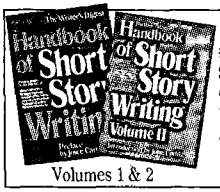

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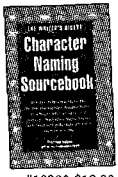

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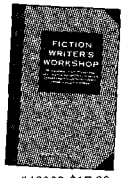

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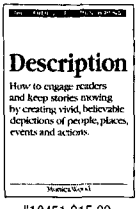
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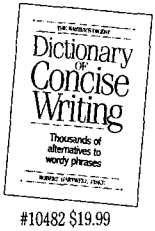

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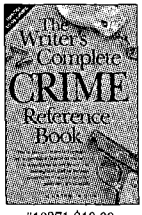

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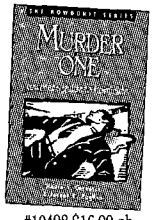

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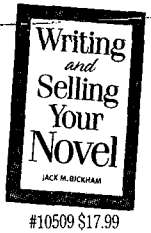

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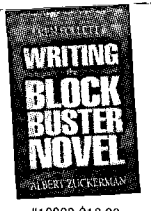

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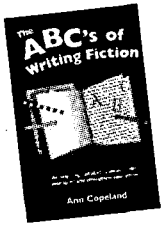

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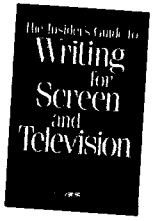

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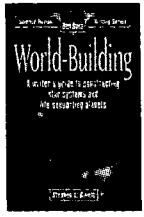

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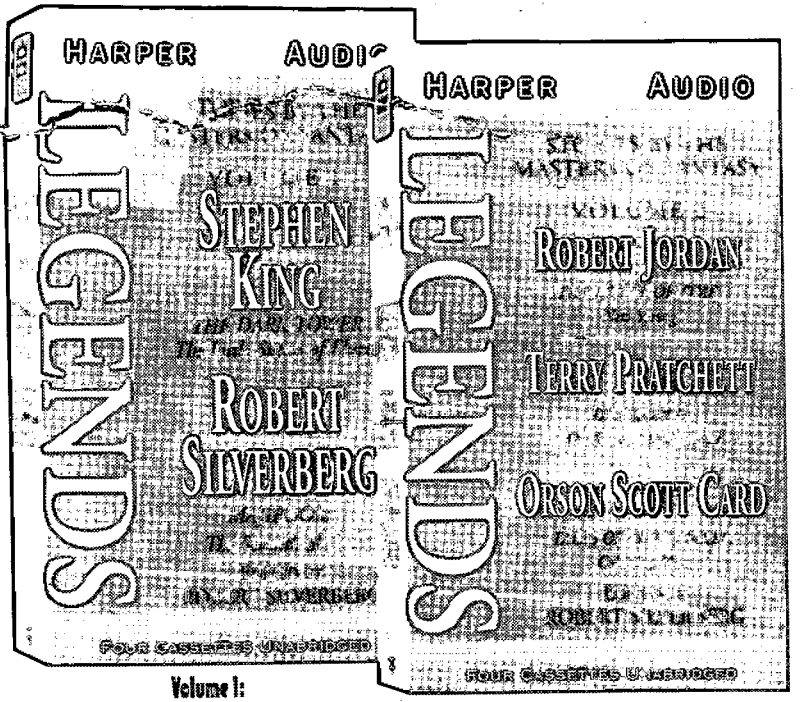

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TIME-UNBINDING

Some years ago, Alfred Korzybski coined the term "time-binding" to describe the human tendency to transmit learned information from one generation to later ones. Korzybski was especially interested in such transmission of information by symbols, such as written or spoken language. That, unlike direct demonstration in real time, makes it possible to communicate about objects that are not present, or concepts that are too abstract to point to—or to communicate with people who are not present, or even not yet born.

In response to my editorial "King of the Hill (No Matter What)," in the July/August 1998 *Analog*, reader Hayward Thresher correctly pointed to time-binding as one of the areas of greatest difference between man and other animals. "What distinguishes man from other animals," Mr. Thresher wrote, "is that he remembers his ancestors and tells of their exploits and lineages. It's an oral tradition which vanishes under the development of writing. (The only reason we know that an ancient Egyptian complained the development of hieroglyphics would lead to the deterioration of men's memory is from the statement being put in writing.)"

This observation is interesting on at least two levels. First, it points out the importance of time-binding. Preliterate humans recognized that if they remembered what their ancestors had done, they could build on it. Thus successive generations could make cumulative progress instead of every generation having to repeat the trials and errors by which the previous one had learned, and therefore progress no further. Second, he is probably right that the general level of memorization skills declined when writing became available—but that's not necessarily a bad thing.

Our preliterate ancestors needed bards who could memorize long epics, and poetic forms to make the process easier, because nothing better was available. Writing *is* something better, provided it's done in a sufficiently durable medium. It serves the same purpose as memorizing rote tales, but does the job better.

If an ancient Egyptian complained as Mr. Thresher suggests, we can know about it because it was written down—and it's most unlikely that we would know if it hadn't been, *even if the oral tradition had been kept at the old level of vitality*. Too much has happened in the intervening millennia; nobody could remember it all, much less have time to recite (or listen to) it all. Writing provides a way to create a communal memory bank far larger than any one mind could hold, and a means for anyone sufficiently interested to access those memories. With writing, we could know what Mr. Thresher's Egyptian thought of this newfangled writing even if his entire civilization and all its descendants died in a plague; with only an oral tradition, all of it would be irrevocably lost.

And the loss would be profoundly important—not specifically for the complaining Egyptian, but for the entire body of knowledge and history his people had accumulated. Time-binding is one of the most fundamental requirements for human progress. As Sir Isaac Newton put it, "If I have seen further than other men, it is because I stood on

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the shoulders of giants." This is not mere modesty (true or false), but a simple statement of important fact. It's highly unlikely that he would have been able to formulate his laws of gravitation and motion without knowledge of the observations of generations of predecessors, or to develop calculus except as an extension of arithmetic and algebra. Much that we take for granted in our civilization is *much* too far removed from the knowledge base of our early ancestors for any one human to be able to make the leap alone. We have what we have only because the brightest members of each generation have seen ways to add something to the knowledge accumulated by the previous generation, which in turn built on the accomplishments of the one before that . . .

And so on—*way* back.

All of which makes it more than a little alarming to see current trends toward time-*un*binding, toward cutting ourselves off from our antecedents—sometimes through simple ignorance or carelessness, sometimes through stupid arrogance.

The "ignorance or carelessness" kind of time-unbinding I dealt with at some length in an earlier essay here ("Continuity," August 1991). The problem here is that in the exuberant flowering of the computer age, we have fallen into the trap of using media that are very fragile and very rapidly changing. An accidental electromagnetic pulse can wipe out whole libraries in a fraction of a second; galloping obsolescence makes stored information inaccessible and unusable in a mere handful of years. Ironically, the very tools that have given us the greatest power in history to manipulate information also threaten to make us the most ephemeral civilization in history. We know a lot about what the Egyptians were doing thousands of years ago; if we continue the worst trends of increasing dependence on fragile and rapidly changing storage media, people may know virtually nothing about us in mere decades.

The good news on that front is that there's a growing recognition of the potential problem, and at least some people are making efforts to make media more durable and to facilitate the transfer of data from older computers to newer ones. So that is not my main concern today. At the moment, I'm more concerned about the "stupid arrogance" kind of time-unbinding.

It took me a while to get that way. When I first started seeing the signs of the problem, the phrase "stupid arrogance" didn't even enter my mind. A few years back, I appeared on a panel at a World Science Fiction Convention about "the growing generation gap in science fiction"—a title that turned out to refer to a tendency for younger readers to know little of older work in the field (and older ones to know little of the newer). At the time, it left me rela-

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tively lukewarm, because I hadn't yet realized the significance and prevalence of the problem.

Since then I've become increasingly aware of many young readers, and even writers, who are totally unfamiliar with the work of their important predecessors. It's surprisingly common, for example, to find people who consider themselves very knowledgeable about science fiction yet have no idea who Robert A. Heinlein or Clifford D. Simak was. The trend is by no means limited to science fiction. I've also met musicians who knew nothing of Beethoven, Joplin, or Ellington. I've heard of philosophy professors devoting all their attention to very recent philosophers and completely ignoring the classics, such as Plato.

Or, worse than ignoring, sneeringly dismissing them as unimportant and irrelevant. It has become fashionable among some young writers to take *pride* in having never read even their most important predecessors, as if ignorance of what's been done before somehow makes their own work "purer" and therefore better. (It was this realization that called the phrase "stupid arrogance" to mind.) It has become fashionable in too many circles to say, "Why should we care what a bunch of old dead guys wrote? They have nothing important to say to us!" There's a fad for merely shrugging off (without looking at it) the work of "dead white males," as if being dead or white or male could automatically mean anyone with those attributes was not worth reading or hearing.

Well, why *should* people now care what their ancestors did? I've already answered that; please see above. Since advancing an art or a science or a civilization depends on each generation building on what all before it have done, you're unlikely to add anything significant unless you understand where you're starting from. You're not going to do the equivalent of inventing calculus unless you already understand the concepts on which calculus builds. And you're not adding anything useful if you spend your life reinventing those concepts, when they're already available in books you disdained to read, and don't go beyond them.

Those who sneer at the idea that there's any reason for them to learn about the classics—or even the previous generation—are just as wrong as those who thought a classical education was *all* you'd ever need. The fun-

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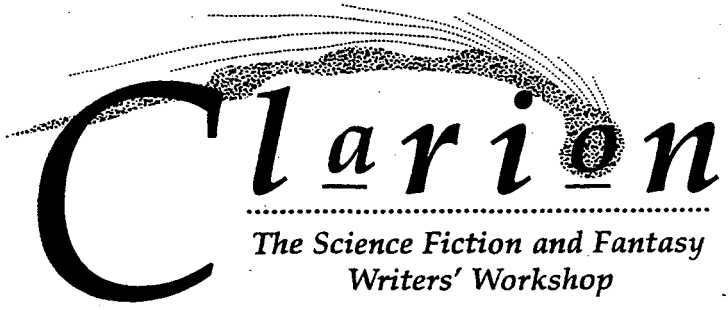

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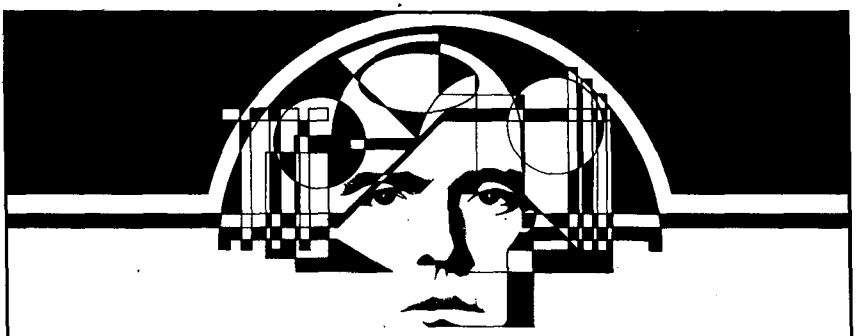
damental importance of time-binding—the reason it must not be allowed to be discarded, either through ignorance or arrogance—is that it enables us to build on the accomplishments of our predecessors instead of continually reinventing the wheel.

People who have no idea what earlier writers did can—and do—kid themselves that the well-worn retreads of ideas in movies and TV shows are fresh and new, that they originated in those shows instead of being recycled without attribution from much older stories. That greatly reduces the chances that such people will ever come up with anything that really *is* fresh and new. And that's just as true in *any* field where people are trying to do new things with no knowledge of the old.

Admittedly it's hard to be familiar with your cultural antecedents, and gets harder all the time, simply because the amount of "old" stuff is constantly growing. Nobody can be familiar with everything new, much less everything old. But it is possible to learn something about the framework and high points, and it's important to do so. If we throw away the effort to time-bind, civilization can easily degenerate into a new kind of stasis, with its members not continually doing the same thing, but repeatedly cycling through the same old things that their abbreviated memories delude themselves are new. ■



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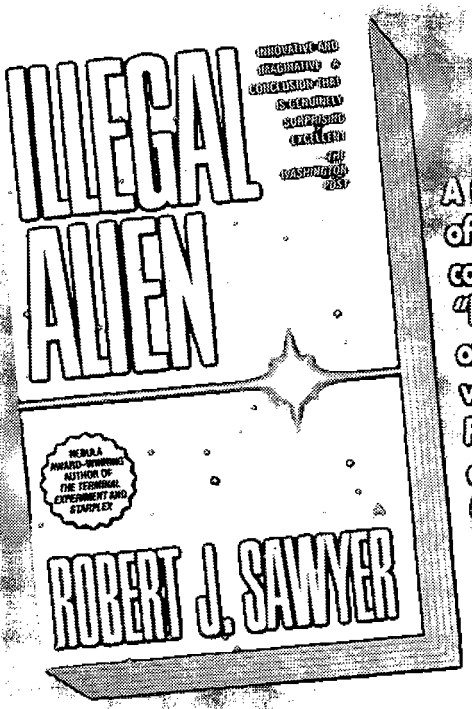
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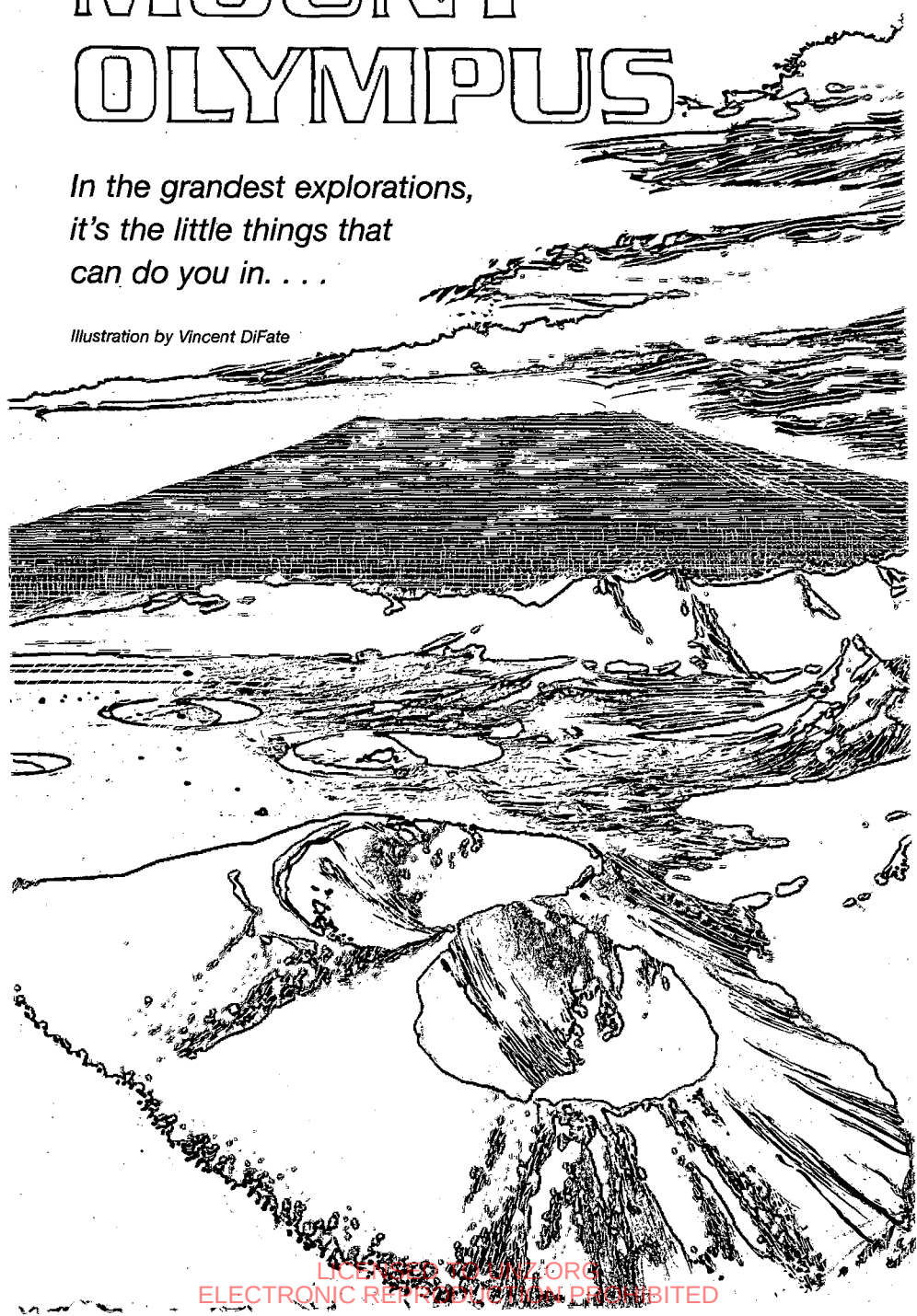

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The tallest mountain in the solar system is Olympus Mons, on Mars. It is a massive shield volcano that has been dormant for tens, perhaps hundreds of millions of years.

Once, though, its mighty outpourings of lava dwarfed everything else on the planet. Over time, they built a mountain three times taller than Everest, with a base the size of the state of Iowa.

The edges of that base are rugged cliffs of basalt more than a kilometer high. The summit of the mountain, where huge calderas mark the vents that once spewed molten rock, stands some twenty-seven kilometers above the supporting plain.

At that altitude, the carbon dioxide that forms the major constituent of Mars's atmosphere can freeze out, condense on the cold, bare rock, covering it with a thin, invisible layer of dry ice.

Tomas Rodriguez looked happy as a puppy with an old sock to chew on as he and Fuchida got into their hard suits.

"I'm gonna be in the Guinness Book of Records," he proclaimed cheerfully to Jamie Waterman, who was helping him get suited up. Trudy Hall was assisting Fuchida while Stacy Dezhurova sat in the comm center, monitoring the dome's systems and the equipment outside.

It was the forty-eighth day of the Second Expedition's eighteen months on the surface of Mars, the day that Rodriguez and biologist Mitsuo Fuchida were scheduled to fly to Olympus Mons.

"Highest aircraft landing and takeoff," Rodriguez chattered cheerfully as he wormed his fingers into the suit's gloves. "Longest flight of a manned solar-powered aircraft. Highest altitude for a manned solar-powered aircraft."

"Crewed," Trudy Hall murmured, "not manned."

Unperturbed by her correction, Rodriguez continued, "I might even bust the record for unmanned solar-powered flight."

"Isn't it cheating to compare a flight on Mars to flights on Earth?" Trudy asked as she helped Fuchida latch his life-support pack onto the back of his suit.

Rodriguez shook his head vigorously. "All that counts in the record book is the numbers, chica. Just the numbers."

"Won't they put an asterisk next to the numbers and a footnote that says, 'This was done on Mars.'?"

Rodriguez tried to shrug but not even he could manage that inside the hard suit. "Who cares, as long as they spell my name right?"

As the two men put on their suit helmets and sealed them to the neck rings, Jamie noticed that Fuchida was utterly silent through the suit-up procedure. Tomas is doing enough talking for them both, he thought. But he wondered, Is Mitsuo worried, nervous? He looks calm enough, but that might just be a mask. Come to think of it, the way Tomas is blathering, he must be wired tighter than a drum.

The bulky hard suits had been pristine white when the explorers first touched down on Mars. Now their boots and leggings were tinged with reddish dust, no matter how hard the explorers vacuumed the ceramic-metal suits each time they returned to the dome's airlock.

Rodriguez was the youngest of the eight explorers, the astronaut that NASA had loaned to the expedition. If it bothered him to work under Dezhurova, the more experienced Russian cosmonaut, he never showed it. All through training and the five-month flight to Mars and their nearly seven weeks on the planet's surface, he had been a good-natured, willing worker. Short and stocky, with a swarthy complexion and thickly curled dark hair, his most noticeable feature was a dazzling smile that made his deep brown eyes sparkle.

But now he was jabbering away like a fast-pitch salesman. Jamie wondered if it

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was nerves or relief to be out on his own, in charge. Or maybe, Jamie thought, the guy was simply overjoyed at the prospect of flying.

Both men were suited up at last, helmet visors down, life-support systems functioning, radio checks completed. Jamie and Trudy walked with them to the airlock hatch: two Earthlings accompanying a pair of ponderous robots.

Jamie shook hands with Rodriguez. His bare hand hardly made it around the astronaut's glove, with its servo-driven exoskeleton "bones" on its back.

"Good luck, Tòmas," he said. "Don't take any unnecessary risks out there."

Rodriguez grinned from behind his visor. "Hey, you know what they say: There are old pilots and bold pilots, but there are no old, bold pilots."

Jamie chuckled politely. As mission director, he felt he had to impart some final words of wisdom. "Remember that when you're out there," he said.

"I will, boss. Don't worry."

Fuchida stepped up to the hatch once Rodriguez went through. Even in the bulky suit, even with sparrowlike Trudy Hall standing behind him, he looked small, somehow vulnerable.

"Good luck, Mitsuo," said Jamie.

Through the sealed helmet, Fuchida's voice sounded muffled, but unafraid. "I think my biggest problem is going to be listening to Tòmas' yakking all the way to the mountain."

Jamie laughed.

"And back, most likely," Fuchida added.

The indicator light turned green and Trudy pressed the stud that opened the inner hatch. Fuchida stepped through, carrying his portable life-support satchel in one hand.

He's all right, Jamie told himself. Mitsuo's not scared or even worried.

Once they had clambered into the plane's side-by-side seats and connected to its internal electrical power and life support systems, both men changed.

Rodriguez became all business. No more chattering. He checked out the plane's systems with only a few clipped words of jargon to Stacy Dezhurova, who was serving as flight controller back in the dome's comm center.

Fuchida, for his part, felt his pulse thundering in his ears so loudly he wondered if the suit radio was picking it up. Certainly the medical monitors must be close to the redline, his heart was racing so hard.

Like the expedition's remotely-piloted soarplanes, the rocketplane was built of gossamer-thin plastic skin stretched over a framework of ceramic-plastic cerplast. To Fuchida it looked like an oversized model airplane made of some kind of kitchen wrap, complete with an odd-looking six-bladed propeller on its nose.

But it was big enough to carry two people. Huge, compared to the unmanned soarplanes. Rodriguez said it was nothing more than a fuel tank with wings. The wings stretched wide, drooping to the ground at their tips. The cockpit was tiny, nothing more than a glass bubble up front. The rocket engines, tucked in where the wing roots joined the fuselage, looked too small to lift the thing off the ground.

The plane was designed to use its rocket engines for takeoffs, then once at altitude, it would run on the prop. Solar panels painted onto the wing's upper surface would provide the electricity to power the electrical engine. There was too little oxygen in the Martian air to run a jet engine; the rockets were the plane's main muscle, the solar cells its secondary energy source.

Back in the dome, Jamie and the others crowded over Dezhurova's shoulders to watch the takeoff on the comm center's desktop display screen.

As an airport, the base left much to be desired. The bulldozed runway ran just short of two kilometers in length. There was no taxiway; Rodriguez and a helper—often Jamie—simply turned the

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fragile plane around after a landing so it was pointed up the runway again. There was no windsock. The atmosphere was so rare that it made scant difference which way the wind was blowing when the plane took off. The rocket engines did most of the work of lifting the plane off the ground and providing the speed it needed for the broad, drooping wings to generate enough lift for flight.

Jamie felt a dull throbbing in his jaw as he bent over Dezhurova, watching the final moments before takeoff. With a conscious effort he unclenched his teeth. There are two men in that plane, he told himself. If anything goes wrong, if they crash, they'll both be killed.

"Clear for takeoff," Dezhurova said mechanically into her lip mike.

"Copy clear," Rodriguez's voice came through the speakers.

Stacy scanned the screens around her one final time, then said, "Clear for ignition."

"Ignition."

Suddenly the twin rocket engines beneath the wing roots shot out a bellowing flame and the plane jerked into motion. As the camera followed it jouncing down the runway, gathering speed, the long, drooping wings seemed to stiffen and stretch out.

"Come on, baby," Dezhurova muttered.

Jamie saw it all as if it were happening in slow motion: the plane trundling down the runway, the rockets' exhaust turning so hot the flame became invisible, clouds of dust and grit billowing behind the plane as it sped faster, faster along the runway, nose lifting now.

"Looking good," Dezhurova whispered.

The plane hurtled up off the ground and arrowed into the pristine sky, leaving a roiling cloud of dust and vapor slowly dissipating along the length of the runway. To Jamie it looked as if the cloud was trying to reach for the plane and pull it back to the ground.

But the plane was little more than a speck in the salmon-pink sky now.

Rodriguez's voice crackled through the speakers, "Next stop, Mount Olympus!"

Rodriguez was a happy man. The plane was responding to his touch like a beautiful woman, gentle and sweet.

They were purring along at—he glanced at the altimeter—twenty-eight thousand and six meters. Let's see, he mused. Something like three point two feet in a meter, that makes it eighty-nine, almost ninety thousand feet. Not bad. Not bad at all.

He knew the world altitude record for a solar-powered plane was above one hundred thousand feet. But that was a UAV, an unmanned aerial vehicle. No pilot's flown this high in a solar-powered plane, he knew. Behind his helmet visor he smiled at the big six-bladed propeller as it spun lazily before his eyes.

Beside him, Fuchida was absolutely silent and unmoving. He might as well be dead inside his suit, I'd never know the difference, Rodriguez thought. He's scared, just plain scared. He doesn't trust me. He's scared of flying with me. Probably wanted Stacy to fly him, not me.

Well, my silent Japanese buddy, I'm the guy you're stuck with, whether you like it or not. So go ahead and sit there like a fuckin' statue, I don't give a damn.

Mitsuo Fuchida felt an unaccustomed tendril of fear worming its way through his innards. This puzzled him, since he had known for almost two years now that he would be flying to the top of Olympus Mons. He had flown simulations hundreds of times. This whole excursion to Olympus Mons had been his idea, and he had worked hard to get the plan incorporated into the expedition schedule.

He had first learned to fly while an undergraduate biology student, and had been elected president of the university's flying club. With the single-minded intensity of a competitor who knew he had to beat the best of the best to win a berth on the Second Mars Expedition,

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Fuchida had taken the time to qualify as a pilot of ultralight aircraft over the inland mountains of his native Kyushu and then went on to pilot soarplanes across the jagged peaks of Sinkiang.

He had never felt any fear of flying. Just the opposite: he had always felt relaxed and happy in the air, free of all the pressures and cares of life.

Yet now, as the sun sank toward the rocky horizon, casting eerie red light across the barren rust-red landscape, Fuchida knew that he was afraid. What if the engine fails? What if Rodriguez cracks up the plane when we land on the mountain? One of the unmanned soarplanes had crashed while it was flying over the volcano on a reconnaissance flight; what if the same thing happens to us?

Even in rugged Sinkiang there was a reasonable chance of surviving an emergency landing. You could breathe the air and walk to a village, even if the trek took many days. Not so here on Mars.

What if Rodriguez gets hurt while we're out there? I have only flown this plane in the simulator; I don't know if I could fly it in reality.

Rodriguez seemed perfectly at ease, happily excited to be flying. He shames me, Fuchida thought. Yet . . . is he truly capable? How will he react in an emergency? Fuchida hoped he would not have to find out.

They passed Pavonis Mons on their left, one of the three giant shield volcanoes that lined up in a row on the eastern side of the Tharsis bulge. It was so big that it stretched out to the horizon and beyond, a massive hump of solid stone that had once oozed red-hot lava across an area the size of Japan. Quiet now. Cold and dead. For how long?

There was a whole line of smaller volcanoes stretching off to the horizon and, beyond them, the hugely massive Olympus Mons. What happened here to create a thousand-kilometer-long chain of volcanoes? Fuchida tried to meditate on that question, but his mind kept coming back to the risks he was undertaking.

And to Elizabeth.

Their wedding had to be a secret. Married persons would not be allowed on the Mars expedition. Worse yet, Mitsuo Fuchida had fallen in love with a foreigner, a young Irish biologist with flame red hair and skin like white porcelain.

"Sleep with her," Fuchida's father advised him, "enjoy her all you want to. But father no children with her! Under no circumstances may you marry her."

Elizabeth Vernon seemed content with that. She loved Mitsuo.

They had met at Tokyo University. Like him, she was a biologist. Unlike him, she had neither the talent nor the drive to get very far in the competition for tenure and a professorship.

"I'll be fine," she told Mitsuo. "Don't ruin your chance for Mars. I'll wait for you."

That was neither good nor fair, in Fuchida's eyes. How could he go to Mars, spend years away from her, expect her to store her emotions in suspended animation for so long?

His father made other demands on him, as well.

"The only man to die on the First Mars Expedition was your cousin, Konoye. He disgraced us all."

Isoruku Konoye suffered a fatal stroke while attempting to explore the smaller moon of Mars, Deimos. His Russian teammate, cosmonaut Leonid Tolbukhin, said that Konoye had panicked, frightened to be outside their spacecraft in nothing more than a spacesuit, disoriented by the looming menace of Deimos' rocky bulk.

"You must redeem the family's honor," Fuchida's father insisted. "You must make the world respect Japan. Your namesake was a great warrior. You must add new honors to his name."

So Mitsuo knew that he could not marry Elizabeth openly, honestly, as he

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wanted to. Instead, he took her to a monastery in the remote mountains of Kyushu, where he had perfected his climbing skills.

"It's not necessary, Mitsuo," Elizabeth protested, once she understood what he wanted to do. "I love you. A ceremony won't change that."

"Would you prefer a Catholic rite?" he asked.

She threw her arms around his neck. He felt tears on her cheek.

When the day came that he had to leave, Mitsuo promised Elizabeth that he would come back to her. "And when I do, we will be married again, openly, for all the world to see."

"Including your father?" she asked wryly.

Mitsuo smiled. "Yes, including even my noble father."

Then he left for Mars, intent on honoring his family's name and returning to the woman he loved.

The excursion plan called for them to land late in the afternoon, almost at sunset, when the low sun cast its longest shadows. That allowed them to take off in daylight, while giving them the best view of their landing area. Every boulder and rock would show in bold relief, allowing them to find the smoothest spot for their landing.

It also meant, Fuchida knew, that they would have to endure the dark frigid hours of night immediately after they landed. What if the batteries fail? The lithium-polymer batteries had been tested for years, Fuchida knew. They stored electricity generated in sunlight by the solar panels and powered the plane's equipment through the long, cold hours of darkness. But what if they break down when the temperature drops to a hundred and fifty below zero?

Rodriguez was making a strange, moaning sound, he realized. Turning sharply to look at the astronaut sitting beside him, Fuchida saw only the inside of his own helmet. He had to turn from the shoulders to see the space-suited pilot—who was humming tunelessly.

"Are you all right?" Fuchida asked nervously.

"Sure."

"Was that a Mexican song you were humming?"

"Naw. The Beatles. 'Lucy in the Sky with Diamonds.'"

"Oh."

Rodriguez sighed happily. "There she is," he said.

"What?"

"Mount Olympus." He pointed straight ahead.

Fuchida did not see a mountain, merely the horizon. It seemed rounded, now that he paid attention to it: a large gently rising hump.

It grew as they approached it. And grew. And grew. Olympus Mons was an immense island unto itself, a continent rising up above the bleak red plain like some gigantic mythical beast. Its slopes were gentle, above the steep scarps of its base. A man could climb that grade easily, Fuchida thought. Then he realized that the mountain was so huge it would take a man weeks to walk from its base to its summit.

Rodriguez was humming again, calm and relaxed as a man sitting in his favorite chair at home.

"You enjoy flying, don't you?" Fuchida commented.

"You know what they say," Rodriguez replied, a serene smile in his voice. "Flying a plane is the second most exciting thing a man can do."

Fuchida nodded inside his helmet. "And the most exciting must be sex, right?"

"Nope. The first most exciting thing a man can do is landing a plane."

Fuchida sank into gloomy silence.

As the senior of the expedition's two astronauts, Anastasia Dezhurova was technically second-in-command to Jamie Waterman. She saw to it that her main duty post was the communica-

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tions center, where she could watch everyone and everything. As long as she was watching, Dezhurova felt, nothing very bad could happen to her fellow explorers.

The dome was quiet, everyone busy at their appointed tasks. Dezhurova could see Waterman outside, doggedly chipping still more rock samples. Trudy Hall was in her lab working with the lichen from the Grand Canyon; the only other woman among them, Vijay Shektar, was in her infirmary, scrolling medical data on her computer.

"Rodriguez to base," the astronaut's voice suddenly crackled in the speaker. "I'm making a dry run over the landing area. Sending my camera view."

"Base to Rodriguez," Dezhurova snapped, all business. "Copy dry run." Her fingers raced over the keyboard and the main display suddenly showed a pockmarked, boulder-strewn stretch of bare rock. "We have your imagery."

Dezhurova felt her mouth go dry. I'd better call Jamie back into the dome. If that's the landing area, they're never going to get down safely.

Rodriguez banked the plane slightly so he could see the ground better. To Fuchida it seemed as if the plane was standing on its left wingtip while the hard, bare rock below turned in a slow circle.

"Well," Rodriguez said, "we've got a choice: boulders or craters."

"Where's the clear area the soarplanes showed?" Fuchida asked.

"'Clear' is a relative term," Rodriguez muttered.

Fuchida swallowed bile. It burned in his throat.

"Rodriguez to base. I'm going to circle the landing area one more time. Tell me if you see anything I miss."

"Copy another circle." Stacy Dezhurova's tone was clipped, professional.

Rodriguez peered hard at the ground below. The setting sun cast long shadows that emphasized every pebble down there. Between a fresh-looking crater and a scattering of rocks was a relatively clean area, more than a kilometer long. Room enough to land if the retros fired on command.

"Looks OK to me," he said into his helmet mike.

"Barely," came Dezhurova's voice.

"The wheels can handle small rocks."

"Shock absorbers are no substitute for level ground, Tòmas."

Rodriguez laughed. He and Dezhurova had gone through this discussion a few dozen times, ever since the first recon photos had come back from the UAVs.

"Turning into final approach," he reported.

Dezhurova did not reply. As the flight controller she had the authority to forbid him to land.

"Lining up for final."

"Your imagery is breaking up a little."

"Light level's sinking fast."

"Yes."

Fuchida saw the ground rushing up toward him. It was covered with boulders and pitted with craters and looked as hard as concrete, harder. They were coming in too fast, he thought. He wanted to grab the control T-stick in front of him and pull up, cut in the rocket engines and get the hell away while they had a chance. Instead, he squeezed his eyes shut.

Something hit the plane so hard that Fuchida thought he'd be driven through the canopy. His safety harness held, though, and within an eyeblink he heard the howling screech of the tiny retro rocket motors. The front of the plane seemed to be on fire. They were bouncing, jolting, rattling along like a tin can kicked across a field of rubble.

Then a final lurch and all the noise and motion stopped.

"We're down," Rodriguez sang out. "Piece of cake."

"Good," came Dezhurova's stolid voice.

Fuchida urgently needed to urinate.

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"OK," Rodriguez said to his partner. "Now we just sit tight until sunrise."

"Like a pair of tinned sardines," said Fuchida.

Rodriguez laughed. "Hey, man, we got all the creature comforts you could want—almost. Like tourist class in an overnight flight."

Fuchida nodded inside his helmet. He did not relish the idea of trying to sleep in the cockpit seats, sealed in their suits. But that was the price to be paid for the honor of being the first humans to set foot on the tallest mountain in the solar system.

Almost, he smiled. I too will be in the Guinness Book of Records, he thought.

"You OK?" Rodriguez asked.

"Yes, certainly."

"Kinda quiet, Mitsuo."

"I'm admiring the view," said Fuchida.

Nothing but a barren expanse of bare rock, in every direction. The sky overhead was darkening swiftly. Already Fuchida could see a few stars staring down at them.

"Well, look on the bright side," Rodriguez quipped. "Now we get to test the FES."

The Fecal Elimination System. Fuchida dreaded the moment when he had to try to use it.

Rodriguez chuckled happily, as if he hadn't a care in the world. In two worlds.

"Never show fear." Tomas Rodriguez learned that as a scrawny asthmatic child, growing up amidst the crime and violence of an inner-city San Diego barrio.

"Never let them see you're scared," his older brother Luis told him. "Never back down from a fight."

Tomas was not physically big, but he had his big brother to protect him. Most of the time. Then he found a refuge of sorts in the dilapidated neighborhood gym, where he traded hours of sweeping and cleaning for free use of the weight machines. As he gained muscle mass, he learned the rudiments of alley fighting from Luis. In middle school he was spotted and recruited by an elderly Korean who taught martial arts as a school volunteer.

In high school he discovered that he was bright, smart enough not merely to understand algebra but to want to understand it and the other mysteries of mathematics and science. He made friends among the nerds as well as the jocks, often protecting the former against the hazing and casual cruelty of the latter.

He grew into a solid, broad-shouldered youth with quick reflexes and the brains to talk his way out of most confrontations. He did not look for fights, but handled himself well enough when a fight became unavoidable. He worked, he learned, he had the kind of sunny disposition—and firm physical courage—that made even the nastiest punks in the school leave him alone. He never went out for any of the school teams and he never did drugs. He didn't even smoke. He couldn't afford such luxuries.

He even avoided the trap that caught most of his buddies: fatherhood. Whether they got married or not, most of the guys quickly got tied down with a woman. Tomas had plenty of girls, and learned even before high school the pleasures of sex. But he never formed a lasting relationship. He didn't want to. The neighborhood girls were attractive, yes, until they started talking. Tomas couldn't stand even to imagine listening to one of them for more than a few hours. They had nothing to say. Their lives were empty. He ached for something more.

Most of the high-school teachers were zeroes, but one—the weary old man who taught math—encouraged him to apply for a scholarship to college. To Tomas' enormous surprise, he won one: full tuition to UCSD. Even so, he could not afford the other expenses, so he again listened to his mentor's advice and

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joined the Air Force. Uncle Sam paid his way through school, and once he graduated he became a jet fighter pilot. "More fun than sex," he would maintain, always adding, "Almost."

Never show fear. That meant that he could never back away from a challenge. Never. Whether in a cockpit or a barroom, the stocky Hispanic kid with the big smile took every confrontation as it arose. He got a reputation for it.

The fear was always there, constantly, but he never let it show. And always there was that inner doubt. That feeling that somehow he didn't really belong here. They were allowing the chicano kid to pretend he was as smart as the white guys, allowing him to get through college on his little scholarship, allowing him to wear a flyboy uniform and play with the hotshot jet planes.

But he really wasn't one of them. That was made abundantly clear to him in a thousand little ways, every day. He was a greaser, tolerated only as long as he stayed in the place they expected him to be. Don't try to climb too far; don't show off too much; above all, don't try to date anyone except "your own."

Flying was different, though. Alone in a plane seven or eight miles up in the sky it was just him and God, the rest of the world far away, out of sight and out of mind.

Then came the chance to win an astronaut's wings. He couldn't back away from the challenge. Again, the others made it clear that he was not welcome to the competition. But Tomas entered anyway and won a slot in the astronaut training corps. "The benefits of affirmative action," one of other pilots jeered.

Whatever he achieved, they always tried to take the joy out of it. Tomas paid no outward attention, as usual; he kept his wounds hidden, his bleeding internal.

Two years after he had won his astronaut's wings came the call for the Second Mars Expedition. Smiling his broadest, Tomas applied. No fear. He kept his gritted teeth hidden from all the others, and won the position.

"Big fuckin' deal," said his buddies. "You'll be second fiddle to some Russian broad."

Tomas shrugged and nodded. "Yeah," he admitted. "I guess I'll have to take orders from everybody."

To himself he added, But I'll be on Mars, shitheads, while you're still down here.

Following his astronaut teammate, Mitsuo Fuchida clambered stiffly down the ladder from the plane's cockpit and set foot on the top of the tallest mountain in the solar system.

In the pale light of the rising sun, it did not look like the top of a mountain to him. He had done a considerable amount of climbing in Japan and Canada and this was nothing like the jagged, snow-capped slabs of granite where the wind whistled like a hurled knife and the clouds scudded by below you.

Here he seemed to be on nothing more dramatic than a wide, fairly flat plain of bare basalt. Pebbles and larger rocks were scattered here and there, but not as thickly as they were back at the base dome. The craters that they had seen from the air were not visible here; at least, he saw nothing that looked like a crater.

But when he looked up he realized how high they were. The sky was a deep blue, instead of its usual salmon pink. The dust particles that reddened the sky of Mars were far below them. At this altitude on Earth they would be up in the stratosphere.

Fuchida wondered if he could see any stars through his visor, maybe find Earth. He turned, trying to orient himself with the rising sun.

"Watch your step," Rodriguez's voice warned in his earphones. "It's—"

Fuchida's boot slid out from under him and he thumped painfully on his rear.

" . . . slippery," Rodriguez finished lamely.

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The astronaut shuffled carefully to Fuchida's side, moving like a man crossing an ice rink in street shoes. He extended a hand to help the biologist up to his feet.

Stiff and aching from a night of sitting in the cockpit, Fuchida now felt a throbbing pain in his backside. I'll have a nasty bruise there, he told himself. Lucky I didn't land on the backpack and break the life-support rig.

"Feels like ice underfoot," Rodriguez said.

"It couldn't be frost, we're up too high for water ice to form."

"Dry ice."

"Ah." Fuchida nodded inside his helmet. "Dry ice. Carbon dioxide from the atmosphere condenses out on the cold rock."

"Yep."

"But dry ice isn't slippery . . . "

"This stuff is."

Fuchida thought quickly. "Perhaps the pressure of our boots on the dry ice causes a thin layer to vaporize."

"So we get a layer of carbon dioxide gas under our boots." Rodriguez immediately grasped the situation.

"Exactly. We skid along on a film of gas, like gas-lubricated ball bearings."

"That's gonna make it damned difficult to move around."

Fuchida wanted to rub his butt, although he knew it was impossible inside the hard suit. "The sun will get rid of the ice."

"I don't think it'll get warm enough up here to vaporize it."

"It sublimes at seventy-eight point five degrees below zero, Celsius," Fuchida recalled.

"At normal pressure," Rodriguez pointed out.

Fuchida looked at the thermometer on his right cuff. "It's already up to forty-two below," he said, feeling cheerful for the first time. "Besides, the lower the pressure, the lower the boiling point."

"Yeah. That's right."

"That patch must have been shaded by the plane's wing," Fuchida pointed out. "The rest of the ground seems clear."

"Then let's go to the beach and get a suntan," Rodriguez said humorlessly.

"No, let's go to the caldera, as planned."

"You think it's safe to walk around?"

Nodding inside his helmet, Fuchida took a tentative step. The ground felt smooth, but not slick. Another step, then another.

"Maybe we should've brought football cleats."

"Not necessary. The ground's OK now."

Rodriguez grunted. "Be careful, anyway."

"Yes, I will."

While Rodriguez relayed his morning report from his suit radio through the more powerful transmitter in the plane, Fuchida unlatched the cargo bay hatch and slid their equipment skid to the ground. Again he marvelled that this plane of plastic and gossamer could carry them and their gear. It seemed quite impossible, yet it was true.

"Are you ready?" he asked Rodriguez, feeling eager now to get going.

"Yep. Lemme check the compass bearing. . . . "

Fuchida did not wait for the astronaut's check. He knew the direction to the caldera as if its coordinates were printed on his heart.

Rodriguez felt a chill of apprehension tingling through him as they stared down into the caldera. It was like being on the edge of an enormous hole in the world, a hole that went all the way down into hell.

"Nietzsche was right," Fuchida said, his voice sounding awed, almost frightened, in Rodriguez's earphones.

Rodriguez had to turn his entire torso from the hips to see the Japanese biologist standing beside him, anonymous in his bulky hard suit except for the blue stripes on his arms.

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"You mean about when you stare into the abyss the abyss stares back."

"You've read Nietzsche?"

Rodriguez grunted. "In Spanish."

"That must have been interesting. I read him in Japanese."

Breaking into a chuckle, Rodriguez said, "So neither one of us can read German, huh?"

It was as good a way as any to break the tension. The caldera was huge, a mammoth pit that stretched from horizon to horizon. Standing there on its lip, looking down into the dark, shadowy depths that dropped away for who knew how far, was distinctly unnerving.

"That's a helluva hole," Rodriguez muttered.

"It's big enough to swallow Mt. Everest," said Fuchida, his voice slightly hollow with awe.

"How long's this beast been dead?" Rodriguez asked.

"Tens of millions of years, at least. Probably much longer. That's one of the things we want to establish while we're here."

"Think it's due for another blow?"

Fuchida laughed shakily. "We'll get plenty of warning, don't worry."

"What, me worry?"

They began to unload the equipment they had dragged on the skid. Its two runners were lined with small Teflon-coated wheels so it could ride along rough ground without needing more than the muscle power of the two men. Much of the equipment was mountaineering gear: chocks and pitons and long coiled lengths of Buckyball cable.

"You really want to go down there?" Rodriguez asked while he drilled holes in the hard basalt for Fuchida to implant geo/met beacons. The instrumentation built into the slim pole would continuously measure ground tremors, heat flow from the planet's interior, air temperature, wind velocity and humidity.

"I spent a lot of time exploring caves," Fuchida answered, gripping one of the beacons in his gloved hands. "I've been preparing for this for a long time."

"Spelunking? You?"

"They call it caving. Spelunking is a term used by non-cavers."

"So you're all set to go down there, huh?"

Fuchida realized that he did not truly want to go. Every time he had entered a cave on Earth he had felt an irrational sense of dread. But he had forced himself to explore the caverns because he knew it would be an important point in his favor in the competition for a berth on the Mars expedition.

"I'm all set," the biologist answered, grunting as he worked the geology/meteorology beacon into its hole.

"It's a dirty job," Rodriguez joked, over the whine of the auger's electric motor, "but somebody's got to do it."

"A man's got to do what a man's got to do," Fuchida replied, matching his teammate's bravado.

Rodriguez laughed. "That ain't Nietzsche."

"No. John Wayne."

They finished all the preliminary work and headed back to the lip of the caldera. Slowly. Reluctantly, Rodriguez thought. Well, he told himself, even if we break our asses poking around down there at least we've got the beacons up and running.

Fuchida stopped to check the readouts coming from the beacons.

"They all transmitting OK?" Rodriguez asked.

"Yes," came the reply in his earphones. "Interesting . . . "

"What?"

"Heat flow from below ground is much higher here than at the dome or even down in the Canyon."

Rodriguez felt his eyebrows crawl upward. "You mean she's still active?"

"No, no, no. That can't be. But there is still some thermal energy down there."

"We should've brought marshmallows."

"Perhaps. Or maybe there'll be some-

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thing to picnic on down there waiting for us!" The biologist's voice sounded excited.

"Whattaya mean?"

"Heat energy! Energy for life, perhaps."

A vision of bad videos flashed through Rodriguez's mind: slimy alien monsters with tentacles and bulging eyes. He forced himself not to laugh aloud. Don't worry, they're only interested in blondes with big boobs.

Fuchida called, "Help me get the lines attached and make certain the anchors are firmly imbedded."

He's not reluctant anymore, Rodriguez saw. He's itching to go down into that huge hole and see what kind of alien creatures he can find.

"You all set?" Rodriguez asked.

Fuchida had the climbing harness buckled over his hard suit, the tether firmly clipped to the yoke that ran under his arms.

"Ready to go," the biologist replied, with an assurance he did not truly feel. That dark, yawning abyss stirred a primal fear in both men, but Fuchida did not want to admit to himself, much less to his teammate.

Rodriguez had spent the morning setting up the climbing rig while Fuchida collected rock samples and then did a half-hour VR show for viewers back on Earth. The rocks were sparser here atop Olympus Mons than they were down on the plains below, and none of them showed the intrusions of color that marked colonies of Martian lichen.

Still, sample collection was the biologist's first order of business. He thought of it as his gift to the geologists, since he felt a dreary certainty that there was no biology going on here on the roof of this world. But down below, inside the caldera . . . that might be a different matter.

Fuchida still had the virtual reality rig clamped to his helmet. They would not do a real-time transmission, but the recording of the first descent into Olympus Mons's main caldera would be very useful both for science and entertainment.

"OK," Rodriguez said, letting his reluctance show in his voice. "I'm ready whenever you are."

Nodding inside his helmet, Fuchida said, "Then let's get started."

"Be careful now," said Rodriguez as the biologist backed slowly away from him.

Fuchida did not reply. He turned and started over the softly rounded lip of the giant hole in the ground. The caldera was so big that it would take half an hour to sink below the level where Rodriguez could still see him without moving from his station beside the tether winch.

I should have read Dante's Inferno in preparation for this task, Fuchida thought to himself.

The road to hell begins with a gradual slope, he knew. It will get steep enough soon.

Then both his booted feet slipped out from under him.

"You OK?" Rodriguez's voice sounded anxious in Fuchida's earphones.

"I hit a slick spot. There must be patches of dry ice coating the rock here in the shadows."

The biologist was lying on his side, his hip throbbing painfully from his fall. At this rate, he thought, I'll be black-and-blue from the waist down.

"Can you get up?"

"Yes. Certainly." Fuchida felt more embarrassed than hurt. He grabbed angrily at the tether and pulled himself to his feet. Even in the one-third gravity of Mars it took an effort, with the suit and backpack weighing him down. And all the equipment that dangled from his belt and harness.

Once on his feet he stared down once more into the darkness of the caldera's yawning maw. It's like the mouth of a great beast, a voice in his mind said. Like the gateway to the eternal pit.

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He took a deep breath, then said into his helmet microphone. "OK. I'm starting down again."

"Be careful, man."

"Thanks for the advice," Fuchida snapped.

Rodriguez seemed untroubled by his irritation. "Maybe I oughta keep the line tighter," he suggested. "Not so much slack."

Regretting his temper, Fuchida agreed, "Yes, that might help to keep me on my feet." The hip really hurt, and his rump was still sore from his first fall.

I'm lucky I didn't rupture the suit, he thought. Or damage the backpack.

"OK, I've adjusted the tension. Take it easy, now."

A journey of a thousand miles must begin with a single step. Mitsuo Fuchida quoted Lao-tzu's ancient dictum as he planted one booted foot on the ground ahead of him. The bare rock seemed to offer good traction.

You can't see the ice, he told himself. It's too thin a coating to be visible. Several dozen meters to his right, sunlight slanted down into the gradually-sloping side of the caldera. There'll be no ice there, Fuchida thought. He moved off in that direction, slowly, testing his footing every step of the way.

The tether connected to his harness at his chest, so he could easily disconnect it if necessary. The increased tension of the line made walking all the more difficult. Fuchida felt almost like a marionette on a string.

"Slack off a little," he called to Rodriguez.

"You sure?"

He turned back to look up his teammate, and was startled to see that the astronaut was nothing more than a tiny blob of a figure up on the rim, standing in bright sunlight with the deep blue sky behind him.

"Yes, I'm certain," he said, with deliberate patience.

A few moments later Rodriguez asked, "How's that?"

The difference was imperceptible, but Fuchida replied, "Better."

He saw a ledge in the sunlight some twenty meters below him and decided to head for it. Slowly, carefully he descended.

"I can't see you." Rodriguez's voice in his earphones sounded only slightly concerned.

Looking up, Fuchida saw the expanse of deep blue sky and nothing else except the gentle slope of the bare rock. And the tether, his lifeline, holding strong.

"It's all right," he said. "I'm using the VR cameras to record my descent. I'm going to stop at a ledge and chip out some rock samples there."

"Hey, Mitsuo," Rodriguez called.

Automatically, Fuchida looked up. But the astronaut was beyond his view. Fuchida was alone down on the ledge in the caldera's sloping flank of solid rock. The Buckyball tether that connected him to the winch up above also carried their suit-to-suit radio transmissions.

"What is it?" he replied, grateful to hear Rodriguez's voice.

"How's it going, man?"

"That depends," said Fuchida.

"On what?"

The biologist hesitated. He had been working on this rock ledge for hours, chipping out samples, measuring heat flow, patiently working an auger into the hard basalt to see if there might be water ice trapped in the rock.

He was in shadow now. The sun had moved away. Looking up, he saw with relief that the sky was still a bright blue. It was still daylight up there. Rodriguez would not let him stay down after sunset, he knew, yet he still felt comforted to see that there was still daylight up there.

"It depends," he answered slowly, "on what you are looking for. Whether you are a geologist or a biologist."

"Oh," said Rodriguez.

"A geologist would be very happy

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here. There is a considerable amount of heat still trapped in these rocks. Much more than can be accounted for by solar warming alone."

"You mean the volcano's still active?"

"No, no, no. It is dead, but the corpse is still warm—a little."

Rodriguez did not reply.

"Do you realize what this means? This volcano must be much younger than was thought. Much younger!"

"How young?"

"Perhaps only a few million years," Fuchida said excitedly. "No more than ten million."

"Sounds pretty damned old to me, amigo."

"But there might be life here! If there is heat, there might be liquid water within the rock."

"I thought water couldn't stay liquid on Mars."

"Not on the surface," Fuchida said, feeling the exhilaration quivering within him. "But deeper down, inside the rock where the pressure is higher . . . maybe . . . "

"Looks pretty dark down there."

"It is," Fuchida answered, peering over the lip of the ledge on which he sat. The suit's heater seemed to be working fine; it might be a hundred below zero in those shadows, but he felt comfortably warm.

"I don't like the idea of your being down there in the dark."

"Neither do I, but that's why we're here, isn't it?"

No answer.

"I mean, we still have several hundred meters of tether to unwind, don't we?"

Rodriguez said, "Eleven hundred and ninety-two, according to the meter."

"So I can go down a long way, then."

"I don't like the dark."

"My helmet lamp is working fine."

"Still . . . "

"Don't worry about it," Fuchida insisted, cutting off the astronaut's worries. It was bad enough to battle his own fears; he wanted no part of Rodriguez's.

"I saw a crevice at the end of this ledge," he told the astronaut. "It looks like the opening of an old lava tube. It probably leads down a considerable distance."

"Do you think that's a good idea?"

"I'll take a look into it."

"Don't take any chances you don't have to."

Fuchida grimaced as he climbed slowly to his feet. His whole body ached from the bruising he'd received in his falls and he felt stiff after sitting on the ledge for so long. Walk carefully, he warned himself. Even though the rock is warmer down here, there could still be patches of ice.

"You hear me?" Rodriguez called.

"If I followed your advice I'd be in my bed in Osaka," he said, trying to make it sound light and witty.

"Yeah, sure."

Stiffly he walked toward the fissure he had seen earlier. His helmet lamp threw a glare of light before him, but he had to bend over slightly to make the light reach the ground.

There it is, he saw. A narrow, slightly rounded hole in the basalt face. Like the mouth of a pirate's cave.

Fuchida took a step into the opening and turned from side to side, playing his helmet lamp on the walls of the cave.

It was a lava tube, he was certain of it. Like a tunnel made by some giant extraterrestrial worm, it curved downward. How far down? he wondered.

Stifling a voice in his head that whispered of fear and danger, Fuchida started into the cold, dark lava tube.

"Jamie," Stacy Dezhurova's voice called out sharply, "we have an emergency message from Rodriguez."

Sitting at the electron microscope in the geology lab, Jamie looked up from the display screen when Dezhurova's voice rang through the dome. He left the core sample in the microscope without turning it off and sprinted across the dome to the comm center.

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Dezhurova looked grim as she silently handed Jamie a headset. The other scientists in the dome crowded into the comm center behind him.

Rodriguez's voice was calm but tight with tension. " . . . down there more than two hours now and then radio contact cut off," the astronaut was saying.

Sitting again on the wheeled chair next to Dezhurova as he adjusted the pin microphone, Jamie said, "This is Waterman. What's happening, Tòmas?"

"Mitsuo went down into the caldera as scheduled. He found a lava tube about fifty-sixty meters down and went into it. Then his radio transmission was cut off."

"How long—"

"It's more than half an hour now. I've tried yanking on his tether but I'm getting no response."

"What do you think?"

"Either he's unconscious or his radio's failed. I mean, I really pulled on the tether. Nothing."

The astronaut did not mention the third possibility: that Fuchida was dead. But the thought blazed in Jamie's mind.

"You say your radio contact with him cut off while he was still in the lava tube?"

"Yeah, right. That was more'n half an hour ago."

A thousand possibilities spun through Jamie's mind. The tether's too tough to break, he knew. Those Buckyballs can take tons of tension.

"It's going to be dark soon," Rodriguez said.

"You're going to have to go down after him," Jamie said.

"I know."

"Just go down far enough to see what's happened to him. Find out what's happened and call back here."

"Yeah. Right."

"I don't like it, but that's what you're going to have to do."

"I don't like it much, either," said Rodriguez.

* * *

Through a haze of pain, Mitsuo Fuchida saw the irony of the situation. He had made a great discovery but he would probably not live to tell anyone about it.

When he entered the lava tube he felt an unaccustomed sense of dread, like a character in an old horror movie, stepping slowly, fearfully down the narrow corridor of a haunted house, lit only by the flicker of a candle. Except this corridor was a tube melted out of the solid rock by an ancient stream of red-hot lava, and Fuchida's light came from the lamp on his hard suit helmet.

Nonsense! he snapped silently. You are safe in your hard suit, and the tether connects you to Rodriguez, up at the surface. But he called to the astronaut and chatted inanely with him, just to reassure himself that he was not truly cut off from the rest of the universe down in this dark, narrow passageway.

The VR cameras fixed to his helmet were recording everything he saw, but Fuchida thought that only a geologist would be interested in this cramped, claustrophobic tunnel.

The tube slanted downward, its walls fairly smooth, almost glassy in places. The black rock gleamed in the light of his lamp. The tunnel grew narrower in spots, then widened again, although nowhere was it wide enough for him to spread his arms fully.

Perspiration was beading Fuchida's lip and brow, trickling coldly down his ribs. Stop this foolishness, he admonished himself. You've been in tighter caves than this.

He thought of Elizabeth, waiting for him back in Japan, accepting the subtle snubs of deep-seated racism because she loved him and wanted to be with him when he returned. I'll get back to you, he vowed, even if this tunnel leads down to hell itself.

The tether seemed to snag from time to time. He had to stop and tug on it to loosen it again. Or perhaps Rodriguez was fiddling with the tension on the line, he thought.

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Deeper into the tunnel he went, stepping cautiously, now and then running his gloved hands over the strangely smooth walls.

Fuchida lost track of time as he chipped at the tunnel walls here and there, filling the sample bags that dangled from his harness belt. The tether made it uncomfortable to push forward, attached to his harness at the chest. It had to pass over his shoulder or around his waist: clumsy, at best.

Then he noticed that the circle of light cast by his helmet lamp showed an indentation off toward the left, a mini-alcove that seemed lighter in color than the rest of the glossy black tunnel walls. Fuchida edged closer to it, leaning slightly into the niche to examine it.

A bubble of lava did this, he thought. The niche was barely big enough for a man to enter. A man not encumbered with a hard suit and bulky backpack, that is. Fuchida stood at the entrance to the narrow niche, peering inside, wondering.

And then he noticed streak of red, the color of iron rust. Rust? Why here and not elsewhere?

He pushed in closer, squeezing into the narrow opening to inspect the rust spot. Yes, definitely the color of iron rust.

He took a scraper from the tool kit at his waist, nearly fumbling it in his awkwardly gloved fingers. If I drop it I won't be able to bend down to pick it up, not in this narrow cleft, he realized.

The red stain crumbled at the touch of the scraper. Strange! thought Fuchida. Not like the basalt at all. Could it be . . . wet? No! Liquid water cannot exist at this low air pressure. But what is the pressure inside the rock? Perhaps . . .

The red stuff crumbled easily into the sample bag he held beneath it with trembling fingers. It must be iron oxide that is being eroded by water, somehow. Water and iron. Siderophiles! Bacteria that metabolize iron and water!

Fuchida was as certain of it as he was of his own existence. His heart was racing. A colony of iron-loving bacteria living inside the caldera of Olympus Mons! Who knew what else might be found deeper down?

It was only when he sealed up the sample bag and placed it in the plastic box dangling from his belt that he heard the strange rumbling sound. Through the thickness of his helmet it sounded muted, far-off, but still any sound at all this deep in the tunnel was startling.

Fuchida started to back away from the crumbling, rust-red cleft. The rumbling sound seemed to grow louder, like the growl of some prowling beast. It was nonsense, of course, but he thought the tunnel walls were shaking slightly, trembling. It's you who are trembling, foolish man! he admonished himself.

Something in the back of his mind said, Fear is healthy. It is nothing to be ashamed of, if you—

The rusted area of rock dissolved into a burst of exploding steam that lifted Fuchida off his feet and slammed him painfully against the far wall of the lava tube.

Fuchida nearly blacked out as his head banged against the back of his helmet. He sagged to the floor of the tunnel, his visor completely fogged, his skull thundering with pain.

With a teeth-gritting effort of iron will he kept himself from slipping into unconsciousness. Despite the pounding in his head, he forced himself to stay awake, alert. Do not faint! he commanded himself. Do not allow yourself to take the cowardly way. You must remain awake if you hope to remain alive. He felt perspiration beading his forehead, dripping into his eyes, forcing him to blink and squint.

Then a wave of anger swept over him. How stupid you are! he railed at himself. A hydrothermal vent. Water. Liquid water, here on Mars. You should have known. You should have guessed. The heat flow, the rusted iron. There must

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be siderophiles here, bacteria that metabolize iron and water. They weakened the wall and you scraped enough of it away for the pressure to blow through the wall.

Yes, he agreed with himself. Now that you've made the discovery, you must live to report it to the rest of the world.

His visor was still badly fogged. Fuchida groped for the control stud at his wrist that would turn up his suit fans and clear the visor. He thought he found the right keypad and pushed it. Nothing changed. In fact, now that he listened for it, he could not hear the soft buzz of his suit fans at all. Except for his own labored breathing, there was nothing but silence.

Wait. Be calm. Think.

Call Rodriguez. Tell him what's happened.

"Tòmas, I've had a little accident."

No response.

"Rodriguez! Can you hear me?"

Silence.

Slowly, carefully, he flexed both his arms, then his legs. His body ached, but there didn't seem to be any broken bones. Still the air fans remained silent, and beads of sweat dripped into his eyes.

Blinking, squinting, he saw that the visor was beginning to clear up on its own. The hydrothermal vent must have been a weak one, he thought thankfully. He could hear no more rumbling; the tunnel did not seem to be shaking now.

Almost reluctantly, he wormed his arm up to eye level and held the wrist keyboard close to his visor. The keyboard was blank. Electrical malfunction! Frantically he tapped at the keyboard: nothing. Heater, heat exchanger, air fans, radio—all gone.

I'm a dead man.

Cold panic hit him like a blow to the heart. That's why you no longer hear the air circulation fans! The suit battery must have been damaged when I slammed against the wall.

Fuchida could hear his pulse thundering in his ears. Calm down! he commanded himself. That's not so bad. The suit has enough air in it for an hour or so. And it's insulated very thoroughly; you won't freeze—not for several hours, at least. You can get by without the air circulation fans. For a while.

It was when he tried to stand up that the real fear hit him. His right ankle flared with agony. Broken or badly sprained, Fuchida realized. I can't stand on it. I can't get out of here.

Then the irony really struck him. I might be the first man to die of heat prostration on Mars.

The problem is, Rodriguez said to himself, that we only have one climbing harness and Mitsuo's wearing it.

I've got to go down there without a tether, without any of the climbing tools that he's carrying with him.

Shit!

The alternative, he knew, was to leave the biologist and return to the safety of the plane. Rodriguez shook his head inside his helmet. Can't leave him. It's already getting dark and he'd never survive overnight.

On the other hand, there's a damned good chance that we'll both die down there.

Double shit.

For long, useless moments he stared down into the dark depths of the caldera, in complete shadow now as the sun crept closer to the distant horizon.

Never show fear, Rodriguez repeated to himself. Not even to yourself. He nodded inside his helmet. Yeah, easy to say. Now get the snakes in my guts to believe it.

Still, he started down, walking slowly, deliberately, gripping the tether hand-over-hand as he descended.

It became totally dark within a few steps of leaving the caldera's rim. The only light was the patch of glow cast by his helmet lamp, and the dark rock all around him seemed to swallow that up greedily. He planted his booted feet care-

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fully, deliberately, knowing that carbon dioxide from the air was already starting to freeze out on the bitterly cold rock.

Rodriguez cast a glance up at the dimming sky, like a prisoner taking his last desperate look at freedom before entering his dungeon.

At least I can follow the tether, he thought. He moved with ponderous deliberation, worried about slipping on patches of ice. If I get disabled we're both toast, he told himself. Take it easy. Don't rush it. Don't make any mistakes.

Slowly, slowly he descended. By the time the tether led him to the mouth of the lava tube, he could no longer see the scant slice of sky above; it was completely black. If there were stars winking at him up there he could not see them through the tinted visor of his helmet.

He peered into the tunnel. It was like staring into a well of blackness.

"Hey Mitsuo!" he called. "Can you hear me?"

No response. He's either dead or unconscious, Rodriguez thought. He's laying deep down that tunnel someplace and I've got to go find him. Or what's left of him.

He took a deep breath. No fear, he reminded himself.

Down the dark tunnel he plodded, ignoring the fluttering of his innards, paying no attention to the voice in his head that told him he'd gone far enough, the guy's dead, no sense getting yourself killed down here too so get the hell out, now.

Can't leave him, Rodriguez shouted silently at the voice. Dead or alive, I can't leave him down here.

Your funeral, the voice countered.

Yeah, sure. I get back to the base OK without him. What're they gonna think of me? How'm I—

He saw the slumped form of the biologist, a lump of hard suit and equipment sitting against one wall of the tunnel.

"Hey, Mitsuo!" he called.

The inert form did not move.

Rodriguez hurried to the biologist and tried to peer into the visor of his helmet. It looked badly fogged.

"Mitsuo," he shouted. "You OK?" It sounded idiotic the moments the words left his lips.

But Fuchida suddenly reached up and gripped his shoulders.

"You're alive!"

Still no answer. His radio's out, Rodriguez finally realized. And the air's too thin to carry my voice.

He touched his helmet against Fuchida's. "Hey, man, what happened?"

"Battery," the biologist replied, his voice muffled but understandable. "Battery not working. And my ankle. Can't walk."

"Jesus! Can you stand up if I prop you?"

"I don't know. My air fans are down. I'm afraid to move; I don't want to generate any extra body heat."

Shit, said Rodriguez to himself. Am I gonna have to carry him all the way up to the surface?

Sitting there trapped like a stupid schoolboy on his first exploration of a cave, Fuchida wished he had paid more attention to his Buddhist instructors. This would be a good time to meditate, to reach for inner peace and attain a calm alpha state. Or was it beta state?

With his suit fans inoperative, the circulation of air inside the heavily-insulated hard suit was almost nonexistent. Heat generated by his body could not be transferred to the heat exchanger in the backpack; the temperature inside the suit was climbing steadily.

Worse, it was more and more difficult to get the carbon dioxide he exhaled out of the suit and into the air recycler. He could choke to death on his own fumes.

The answer was to be as still as possible, not to move, not even to blink. Be calm. Achieve nothingness. Do not stir. Wait. Wait for help.

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Rodriguez will come for me, he told himself. Tomas won't leave me here to die. He'll come for me.

Will he come in time? Fuchida tried to shut the possibility of death out of his thoughts, but he knew that it was the ultimate inevitability.

The hell of it is, I'm certain I have a bag-full of siderophiles! I'll be famous. Posthumously.

Then he saw the bobbing light of a helmet lamp approaching. He nearly blubbered with relief. Rodriguez appeared, a lumbering robotlike creature in the bulky hard suit. To Fuchida he looked sweeter than an angel.

Once Rodriguez realized that he had to touch helmets to be heard, he asked, "How in the hell did you get yourself banged up like this?"

"Hydrothermal vent," Fuchida replied. "It knocked me clear across the tunnel."

Rodriguez grunted. "Old Faithful strikes on Mars."

Fuchida tried to laugh; what came out was a shaky coughing giggle.

"Can you move? Get up?"

"I think so . . . " Slowly, with Rodriguez lifting from beneath his armpits, Fuchida got to his feet. He took a deep breath, then coughed. When he tried to put some weight on his bad ankle he nearly collapsed.

"Take it easy, buddy. Lean on me. We got to get you back to the plane before you choke to death."

Rodriguez had forgotten about the ice.

He half-dragged Fuchida along the tunnel, the little pools of light made by their helmet lamps the only break in the total, overwhelming darkness around them.

"How you doing, buddy?" he asked the Japanese biologist. "Talk to me."

Leaning his helmet against the astronaut's, Fuchida answered, "I feel hot. Broiling."

"You're lucky. I'm freezing my ass off. I think my suit heater's crapping out on me."

"I . . . I don't know how long I can last without the air fans," Fuchida said, his voice trembling slightly. "I feel a little lightheaded."

"No problem," Rodriguez replied, with a false heartiness. "It'll get kinda stuffy inside your suit, but you won't asphyxiate."

The first American astronaut to take an EVA spacewalk outside his capsule had almost collapsed from heat prostration, Rodriguez remembered. The damned suits hold all your body heat inside; that's why they make us wear the watercooled longjohns and put a heat exchangers in the suits. But if the fans can't circulate the air the exchanger's pretty damned useless.

Rodriguez kept one hand on the tether. In the wan light from his helmet lamp he saw that it led upward, out of this abyss.

"We'll be back in the plane in half an hour, maybe less. I can fix your backpack then."

"Good," said Fuchida. Then he coughed again.

It seemed to take hours before they got out of the tunnel, back onto the ledge in the slope of the giant caldera.

"Come on, grab the tether. We're goin' up."

"Right."

But Rodriguez's boot slipped and he fell to his knees with a painful thump.

"Damn," he muttered. "It's slick."

"The ice."

The astronaut rocked back onto his haunches, both knees throbbing painfully.

"It's too slippery to climb?" Fuchida's voice was edging toward panic.

"Yeah. We're gonna have to haul ourselves up with the winch." He got down onto his belly and motioned the biologist to do the same.

"Isn't this dangerous? What if we tear our suits?"

Rodriguez rapped on the shoulder of

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Fuchida's suit. "Tough as steel, amigo. They won't rip."

"You're certain?"

"You wanna spend the night down here?"

Fuchida grabbed the tether with both his hands.

Grinning to himself, Rodriguez also grasped the tether and told Fuchida to activate the winch.

But within seconds he felt the tether slacken.

"Stop!"

"What's wrong?" Fuchida asked.

Rodriguez gave the tether a few light tugs. It felt loose, its original tension gone.

"Holy shit," he muttered.

"What is it?"

"The weight of both of us on the line is too much for the rig to hold. We're pulling it out of the ground up there."

"You mean we're stuck here?"

"I see that none of us are going to get any sleep."

Stacy Dezhurova was smiling as she spoke, but her bright blue eyes were dead serious. Trudy Hall was still on duty at the comm console. Stacy sat beside her while Jamie paced slowly back and forth behind her. Vijay Shektar, the expedition doctor, had pulled in another chair and sat by the doorway, watching them all.

The comm center cubicle felt stuffy and hot with all four of them crowded in there. Jamie did not answer Dezhurova's remark; he just kept on pacing, five strides from one partition to the other, then back again.

"Rodriguez must have found him by now," Hall said, swivelling her chair slightly toward Stacy.

"Then why doesn't he call in?" she demanded, almost angrily.

"They must still be down inside the caldera," Jamie said.

"It's night," Stacy pointed out.

Jamie nodded and kept pacing.

"It's the waiting that's the worst," Vijay offered. "Not knowing what—"

"This is Rodriguez," the radio speaker crackled. "We got a little problem here."

Jamie was at the comm console like a shot, leaning between the two women.

"What's happening, Tòmas?"

"Fuchida's alive. But his backpack's banged up and his battery's not functioning. Heater, air fans, nothing in his suit's working." Rodriguez's voice sounded tense but in control, like a pilot whose jet engine had just flamed out: trouble, but nothing that can't be handled. Until you hit the ground.

Then he added, "We're stuck on a ledge about thirty meters down and can't get back up 'cause the rock's coated with dry ice and it's too slippery to climb."

As the astronaut went on to describe how the tether winch almost pulled out of its supports when the two of them tried to haul themselves up the slope, Jamie tapped Hall on the shoulder and told her to pull up the specs on the hard suit's air circulation system.

"OK," he said when Rodriguez stopped talking. "Are either of you hurt?"

"I'm bruised a little, Mitsuo's got a bad ankle. He can't stand on it."

One of the screens on the console now showed a diagram of the suit's air circulation system. Hall was scrolling through a long list on the screen next to it.

"Mitsuo, how do you feel?" Jamie asked, stalling for time, time to think, time to get the information he needed.

"His radio's down," Rodriguez said. A hesitation, then, "But he says he's hot. Sweating."

Vijay nodded and murmured, "Hyperthermia."

Strangely, Rodriguez chuckled. "Mitsuo also says he discovered siderophiles, inside the caldera! He wants Trudy to know that."

"I heard it," Hall said, still scrolling down the suit specs. "Did he get samples?"

Again a wait, then Rodriguez replied,

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"Yep. There's water in the rock. Liquid water. Mitsuo says you've gotta publish . . . get it out on the Net."

"Liquid?" Hall stopped the scrolling. Her eyes went wide. "Are you certain about—"

"Never mind that now," Jamie said, studying the numbers on Hall's screen. "According to the suit specs you can get enough breathable air for two hours, at least, even with the fans off."

"We can't wait down here until daylight, then," Rodriguez said.

Jamie said, "Tòmas, is Mitsuo's harness still connected to the winch?"

"Far as I can see, yeah. But if we try to use the winch to haul us up it's gonna yank the rig right out of the ground."

"Then Mitsuo's got to go up by himself."

"By himself?"

"Right," Jamie said. "Let the winch pull Mitsuo up to the top. Then he takes off the harness and sends it back to you so you can get up. Understand?"

In the pale light of the helmet lamps, Fuchida could not see Rodriguez's face behind his tinted visor. But he knew what the astronaut must be feeling.

Pressing his helmet against Rodriguez's, he said, "I can't leave you down here alone, without even the tether." Rodriguez's helmet mike must have picked up his voice, because Waterman replied, iron hard, "No arguments, Mitsuo. You drag your butt up there and send the harness back down. It shouldn't take more than a few minutes to get you both up to the top."

Fuchida started to object, but Rodriguez cut him off. "OK, Jamie. Sounds good. We'll call you from the top when we get there."

Fuchida heard the connection click off.

"I can't leave you here," he said, feeling almost desperate.

"That's what you've got to do, man. Otherwise neither one of us will make it."

"Then you go first and send the harness back down to me."

"No way," Rodriguez said. "You're the scientist, you're more important. I'm the astronaut, I'm trained to deal with dangerous situations."

Fuchida said, "But it's my fault—"

"Bullshit," Rodriguez snapped. Then he added, "Besides, I'm bigger and meaner than you. Now get going and stop wasting time!"

"How will you find the harness in the dark? It could be dangling two meters from your nose and your helmet lamp won't pick it up."

Rodriguez made a huffing sound, almost a snort. "Tie one of the beacons to it and turn on the beacon light."

Fuchida felt mortified. I should have thought of that. It's so simple. I must be truly rattled, my mind is not functioning as it should.

"Now go on," Rodriguez said. "Get down on your belly again and start up the winch."

"Wait," Fuchida said. "There is something—"

"What?" Rodriguez demanded impatiently.

Fuchida hesitated, then spoke all in a rush. "If . . . if I don't make it . . . if I die . . . would you contact someone for me when you get back to Earth?"

"You're not gonna die."

"Her name is Elizabeth Vernon," Fuchida went on, afraid that if he stopped he would not be able to resume. "She's a lab assistant in the biology department of the University of Tokyo. Tell her . . . that I love her."

Rodriguez understood the importance of his companion's words. "Your girlfriend's not Japanese?"

"My wife," Fuchida answered.

Rodriguez whistled softly. Then, "OK, Mitsuo. Sure. I'll tell her. But you can tell her yourself. You're not gonna die."

"Of course. But if . . . "

"Yeah. I know. Now get going!"

Reluctantly, Fuchida did as he was told. He felt terribly afraid of a thousand

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possibilities, from tearing his suit to leaving his partner in the dark to freeze to death. But he felt more afraid of remaining there and doing nothing.

Worse, he felt hot. Stifling inside the suit. Gritting his teeth, he held on to the tether with all the pressure the servomotors on his gloves could apply. Then he realized that he need one hand free to work the winch control on his climbing harness.

He fumbled for the control stud, desperately trying to remember which one started the winch. He found it and pressed. For an instant nothing happened.

Then suddenly he was yanked off the ledge and dragged up the hard rock face of the caldera's slope, his suit grinding, grating, screeching against the rough rock.

I'll never make it, Fuchida realized. Even if the suit doesn't break apart, I'll suffocate in here before I reach the top.

Rodriguez watched Fuchida slither up and away from him, a dim pool of light that receded slowly but steadily. Through the insulation of his helmet he could not hear the noise of the biologist's hard suit grating against the ice-rimed rock; he heard nothing but his own breathing, faster than it should have been. Calm down, he ordered himself. Keep calm and everything'll turn out OK.

Sure, a sardonic voice in his head answered. Nothing to it. Piece of cake.

Then he realized that he was totally, utterly alone in the darkness.

It's OK, he told himself. Mitsuo'll send the harness down and then I can winch myself up.

The light cast by his helmet lamp was only a feeble glow against the dark rough rock face. When Rodriguez turned, the light was swallowed by the emptiness of the caldera's abyss, deep and wide and endless.

The darkness surrounded him. It was as if there was no one else in the whole universe, no universe at all, only the all-engulfing darkness of this cold, black pit.

Unbidden, a line from some play he had read years earlier in school came to his mind:

Why, this is hell, nor am I out of it.

Don't be a goon! he snapped at himself. You'll be OK. Your suit's working fine and Mitsuo's up there by now, taking off the harness and getting ready to send it down to you.

Yeah, sure. He could be unconscious, he could be snagged on a rock or maybe the damned harness broke while the winch was dragging him up the slope.

Rodriguez put a gloved hand against the solid rock to steady himself. You'll be out of this soon, he repeated silently. Then he wondered if his lamp's light was weakening. Are the batteries starting to run down?

Fuchida's head was banging against the inside of his helmet so hard he tasted blood in his mouth. He squeezed his eyes shut and saw his father's stern, uncompromising glare. How disappointed he will be when he learns that I died on Mars, like cousin Konoye.

And Elizabeth. Perhaps it's better this way. She can go back to Ireland and find a man of her own culture to marry. My death will spare her a lifetime of troubles.

The winch stopped suddenly and Fuchida felt a pang of terror. It's stuck! He realized at that moment that he was not prepared for death. He did not want to die. Not here on Mars. Not at all.

A baleful red eye was staring at him. Fuchida thought for a moment he might be slipping into unconsciousness, then slowly realized that it was the light atop one of the geo/met beacons they had planted at the lip of the caldera.

Straining his eyes in the starlit darkness, he thought he could make out the form of the winch looming above his prostrate body. He reached out and touched it.

Yes! He had reached the top. But he

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felt faint, giddy. His body was soaked with perspiration. Heat prostration, he thought. How funny to die of heat prostration when the temperature outside my suit is nearly two hundred degrees below zero.

He began to laugh, knowing he was slipping into hysteria and unable to stop himself. Until he began coughing uncontrollably.

Down on the ledge, Rodriguez tried to keep his own terrors at bay.

"Mitsuo," he called on the suit-to-suit frequency. "You OK?"

No answer. Of course, dummy! His radio's not working. The cold seemed to be leaching into his suit. Cold enough to freeze carbon dioxide. Cold enough to overpower the suit's heater. Cold enough to kill.

"Get up there, Mitsuo," he whispered. "Get up there in one piece and send the damned tether back down to me."

He wouldn't leave me here. Not if he made it to the top. He wouldn't run for the plane and leave me here. He can't run, anyway. Can't even walk. But he could make it to the plane once he's up there. Hobble, jump on one leg. He wouldn't do that. He wouldn't leave me alone to die down here. Something must've happened to him. He must be hurt or unconscious.

The memory of his big brother's death came flooding back to him. In a sudden rush he saw Luis's bloody mangled body as the rescue workers lifted him out of the wrecked semi. A police chase on the freeway. All those years his brother had been running drugs up from Tijuana in his eighteen-wheeler and Tomas never knew, never even suspected. There was nothing he could do. By the time he saw Luis's rig sprawled along the shoulder of the highway it was already too late.

He saw himself standing, impotent, inert, as his brother was pronounced dead and then slid into the waiting ambulance and carried away. Just like that. Death can strike like a lightning bolt.

What could I have done to save him? Rodriguez wondered for the thousandth time. I should have done something. But I was too busy being a flyboy, training to be an astronaut. I didn't have time for the family, for my own brother.

He took a deep, sighing breath of canned air. Well, now it's going to even out. I got all the way to Mars, and now I'm gonna die here.

Then he heard his brother's soft, musical voice. "No fear, muchacho. Never show fear. Not even to yourself."

Rodriguez felt no fear. Just a deep eternal sadness that he did not help Luis when help was needed. And now it was all going to end. All the regrets, all the hopes, everything . . .

For an instant he thought he saw a flash of dim red light against the rock wall. He blinked. Nothing. He looked up, but the top of his helmet cut off his view. Grasping at straws, he told himself. You want to see something bad enough, you'll see it, even if it isn't really there.

But the dim red glow flashed again, and this time when he blinked it didn't go away. Damned helmets! he raged. Can't see anything unless it's in front of your fuckin' face.

He tried to tilt his whole upper body back a little, urgently aware that it wouldn't take much to slip off this ledge and go toppling down into the bottomless caldera.

And there it was! The red glow of the beacon's light swayed far above him, like the unwinking eye of an all-seeing savior.

He leaned against the rock face again. His legs felt weak, rubbery. Shit, man, you were really scared.

He could make out the dangling form of the harness now, with the telescoped pole of the beacon attached to it by duct tape. Where the hell did Mitsuo get duct tape? he wondered. He must've been carrying it with him all along. The uni-

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versal cure-all. We could do a commercial for the stuff when we get back to Earth. Save your life on Mars with friggin' duct tape.

It seemed to take an hour for the tiny red light to get close enough to grab. With hands that trembled only slightly, Rodriguez reached up and grabbed the beacon, ripped it free and worked his arms into the climbing harness. Then he snapped its fasteners shut and gave the tether an experimental tug. It felt strong, good.

He started to reach for the control stud that would activate the winch. Then he caught himself. "Wait one," he whispered, in the clipped tone of the professional flier.

He bent down and picked up the beacon. Sliding it open to its full length, he worked its pointed end into a crack in the basalt rock face. It probably won't stay in place for long, he thought, and it won't work at all unless the sun shines on it for a few hours per day. But he felt satisfied that he had left a reminder that men from Earth had been here, had entered the pit and gleaned at least some of its secrets and survived—maybe.

"OK," he said to himself, grasping the tether with one hand. "Here we go."

He pushed on the control stud and was hauled off his feet. Grinding, twisting, grating he felt himself pulled up the rock slope, his head banging inside his helmet, his legs and booted feet bouncing as he was dragged upward.

Worse than any simulator ride he'd ever been through in training. Worse than the high-g centrifuge they'd whirled him in. They'll never put this ride into Disneyland, Rodriguez thought, teeth clacking as he bounced, jounced, jolted up to the lip of the caldera.

At last it was over. Rodriguez lay panting, breathless, aching. Fuchida's hard-suited form lay on the ground next to him, unmoving.

Rodriguez rolled over on one side, as far as his backpack would allow. Beyond Fuchida's dark silhouette the sky was filled with stars. Dazzling bright friendly stars gleaming down at him, like a thousand thousand jewels. Like heaven itself.

I made it, Rodriguez told himself. Then he corrected: Not yet. Can't say that yet.

He touched his helmet to Fuchida's. "Hey, Mitsuo! You OK?"

It was an inane question and he knew it. Fuchida made no response, but Rodriguez that he could hear the biologist's breathing: panting, really, shallow and fast.

Gotta get him to the plane. Can't do a thing for him out here.

As quickly as he could Rodriguez unbuckled the climbing harness, then tenderly lifted the unconscious Fuchida and struggled to his feet. Good thing we're on Mars. I could never lift him in his suit in a full g. Now where the hell is the plane?

In the distance he saw the single red eye of another one of the geo/met beacons they had planted. He headed in that direction, tenderly carrying his companion in his arms.

I couldn't do this for you, Luis, Rodriguez said silently. I wish I could have, but this is the most I can do.

The base dome was dark and silent, its lighting turned down to sleep shift level, its plastic skin opaqued to prevent heat from leaking out into the Martian night. Stacy Dezhurova was still sitting at the comm console, drowsing despite herself, when Rodriguez's call came through.

"We're back in the plane," the astronaut announced without preamble. "Lemme talk to Vijay."

"Vijay!" Stacy shouted in a voice that shattered the sleepy silence. "Jamie!" she added.

Running footsteps padded through the shadows, bare or stockinged feet against the plastic flooring. Vijay, the physician, slipped into a chair beside Dezhurova, her jet-black eyes wide open

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and alert. Jamie and Tracy Hall raced in, bleary-eyed, and stood behind the two women.

"This is Vijay," she said. "What's your condition?"

In the display screen they could see only the two men's helmets and shoulders. Their faces were masked by the heavily tinted visors. But Rodriguez's voice sounded steady, firm.

"I'm OK. Banged up a little, but that's nothing. I purged Mitsuo's suit and plugged him into the plane's emergency air supply. But he's still out of it."

"How long ago did you do that?" Vijay asked, her dark face rigid with tension.

"Fifteen—sixteen minutes ago."

"And you're just calling in now?" Dezhurova demanded.

"I had to fix his battery pack," Rodriguez answered, unruffled by her tone. "It got disconnected when he was knocked down—"

"Knocked down?" Jamie blurted.

"Yeah. That's when he hurt his ankle."

"How badly is he hurt?" Vijay asked.

"It's sprained, at least. Maybe a break."

"He couldn't break a bone inside the suit," Jamie muttered. "Not with all that protection."

"Anyway," Rodriguez resumed, "his suit wasn't getting any power. I figured that getting his suit powered up was the second most important thing to do. Pumping fresh air into him was the first."

"And calling in, the third," Dezhurova said, much more mildly.

"Right," said Rodriguez.

"I'm getting his readouts," Vijay said, studying the medical diagnostic screen.

"Yeah, his suit's OK now that the battery's reconnected."

"Is his LCG working?" Vijay asked.

"Should be," Rodriguez said. "Wait one . . ."

They saw the astronaut lean over and touch his helmet to the unconscious Fuchida's shoulder.

"Yep," he announced, after a moment. "I can hear the pump chugging. Water oughtta be circulating through his longjohns just fine."

"That should bring his temperature down," Vijay muttered, half to herself. "The problem is, he might be in shock from overheating."

"What do I do about that?" Rodriguez asked.

The physician shook her head. "Not much you can do, mate. Especially with the two of you sealed into your suits."

For a long moment they were all silent. Vijay stared at the medical screen. Fuchida's temperature was coming down. Heart rate slowing nicely. Breathing almost normal. He should be—

The biologist coughed and stirred. "What happened?" he asked weakly.

All four of the people at the comm center broke into grins. None of them could see Rodriguez's face behind his visor, but they heard the relief in his voice:

"Naw, Mitsuo; you're supposed to ask, 'Where am I?'"

The biologist sat up straighter. "Is Tracy there?"

"Don't worry about—"

"I'm right here, Mitsuo," said Tracy Hall, leaning in between Dezhurova and Vijay Shektar. "What is it?"

"Siderophiles!" Fuchida exclaimed. "Iron-eating bacteria live in the caldera."

"Did you get samples?"

"Yes, of course."

Jamie stepped back as the two biologists chattered together. Fuchida nearly gets himself killed, but what's important to him is finding a new kind of organism. With an inward smile, Jamie admitted, Maybe he's right.

Jamie awoke the instant the dome's lighting turned up to daytime level. He pushed back the thin sheet that covered him and got to his feet. After the long night they had all put in, he should have felt tired, drained. Yet he was awake, alert, eager to start the day.

Quickly he stepped to his desk and

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booted up his laptop, then opened the communications channel to Rodriguez and Fuchida. With a glance at the desktop clock he saw that it was six-thirty-three. He hesitated for only a moment, though, then put through a call to the two men at Olympus Mons.

As he suspected, they were both awake. Jamie's laptop screen showed the two of them side-by-side in the plane's cockpit.

"Good morning," he said. "Did you sleep well?"

"Extremely well," said Fuchida.

"This cockpit looked like the best hotel suite in the world when we got into it last night," Rodriguez said.

Jamie nodded. "Yeah, I guess it did."

Rodriguez gave a crisp, terse morning report. Fuchida happily praised the astronaut for purging his suit of the foul air and fixing the electrical connection that had worked loose in his backpack.

"My suit fans are buzzing faithfully," he said. "But I'm afraid I won't be able to do much useful work on my bad ankle."

They had discussed the ankle injury the previous night, once Fuchida had regained consciousness. Vijay guessed that it was a sprain, but wanted to get the biologist back to the dome as quickly as possible for an x-ray.

Jamie had decided to let Rodriguez carry out as much of their planned work as he could, alone, before returning. Their schedule called for another half day on the mountaintop, then a takeoff in the early afternoon for the flight back to dome. They should land at the base well before sunset.

"I'll be happy to take off this suit," Fuchida confessed.

"We're not gonna smell so good when we do," Rodriguez added.

Jamie found himself peering hard at the small screen of his laptop, trying to see past their visors. Impossible, of course. But they both sounded cheerful enough. The fears and dangers of the previous night were gone, daylight and the relative safety of the plane brightened their outlook.

Rodriguez said, "We've decided that I'm going back down inside the caldera and properly implant the beacon we left on the ledge there."

"So we can get good data from it," Fuchida added, as if he were afraid Jamie would countermand his decision.

Jamie asked, "Do you really think you should try that?"

"Oughtta be simple enough," Rodriguez said easily, "long as we don't go near that damned lava tube again."

"That's the imperial 'we,'" Fuchida explained. "I'm staying here in the plane, I'm afraid."

"Is there enough sunlight where you want to plant the beacon?" Jamie asked.

He sensed the biologist nodding inside his helmet. "Oh yes, the ledge receives a few hours of sunlight each day."

"So we'll get data from inside the caldera," Rodriguez prompted.

"Not very far inside," Fuchida added, "but it will better than no data at all."

"You're really set on doing this?"

"Yes," they both said. Jamie could feel their determination. It was their little victory over Olympus Mons, their way of telling themselves that they were not afraid of the giant volcano.

"OK, then," Jamie said. "But be careful, now."

"We're always careful," said Fuchida.

"Most of the time," Rodriguez added, with a laugh. ■

"Mount Olympus" is an excerpt from Ben Bova's forthcoming novel, Return to Mars.

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Stephen L. Gillett, Ph.D.

DIGITAL MATTER

People tend to think of the "normal" and "quantum" worlds as separate and alien to each other — but of course they aren't.

Quantum mechanics. Even among —or perhaps, *especially* among— the scientific-minded, it's often something of an embarrassment. In fact, one hard science fiction writer posits in his stories a congruent "continuum" universe, in which there are "no known quantum effects." This is as naïve, if as superficially reasonable, as saying that "Superman's super powers result because Krypton's gravity was so much greater than Earth's."

For everyday matter is a quantum-mechanical effect! Quantum effects are not just weird marginalia—superconductivity, Josephson junctions, helium superfluidity, and that preposterous "uncertainty principle"—that could be swept away in a "reasonable" universe. They are fundamental to our world.

Even the late Isaac Asimov, as great a science rationalist as there ever was, and a science-explainer nonpareil, seemed uncomfortable with quantum mechanics. A mere handful of his hundreds of classic science essays deal with quantum-mechanical matters, and in a number of essays (e.g., Asimov, 1978), he explicitly said he didn't want to deal with QM. Indeed, his many essays on chemical subjects deal with empirical chemistry, with only passing references to the enormous success of QM in explaining the entire panoply of chemical knowledge. The seemingly arbitrary rules of chemical bonding, for

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example, or the structure of the Periodic Table, are both direct consequences of QM.

To an outsider, this queasiness about what is commonly, and correctly, described as the most successful physical theory ever no doubt seems remarkable. But we all know why. For many of us, QM *is* a scientific embarrassment. It's weird, even subjective; it has an air of mysticism at odds with the objective view of reality as something "out there" that we can poke and prod at will. We create something *ex nihilo* just by *measuring* it? Come on!

And naïve non-scientists, including some in academia, have seized gleefully on QM as puncturing the pretense of Science to describe a real, objective world. If what's there depends on what you measure, then isn't "physical reality" as much a social construct as divorce laws or Impressionism? And such reasoning then degenerates into complete moral relativism, with the consequent collapse of values and standards, soaring rates of teen pregnancy, the loss of the Vietnam war, etc., etc. . . .

Well, all right, maybe not. But it's little wonder that Hard-Headed Engineers (HHEs) and applied scientists*, versed in Newtonian physics, classical electricity, and empirical chemistry, and with a deep, intuitive sense of how the macroscopic world should behave, have tended to view QM askance. And they've tended to shuffle their feet and change the subject when confronted with queries about just what does this QM stuff mean for science?

But this reaction is also exaggerated. Sure, some aspects of QM are downright weird. And some aspects are just plain exasperating. (Whaddaya *mean* we can't determine a particle's position and velocity simultaneously!?) But the "subjective" part is overstated. In fact, it's just plain wrong. Quantum mechanics describes a reality that's "out there," and the fact that that reality doesn't react as we intuitively expect, based on our macroscopic experience, doesn't make it less real. It just means we must revise our intuitions.

Quantum Mystification

"Euclid alone has looked on beauty bare."

—Edna St. Vincent Millay

What's worse is that we can't even blame this "quantum mystification" on too much bad popularization. Or at least not completely. Sure, lots of popular writing waxes overly mystical on the weirder phenomena, while glossing over the not-so-weird, and all the while ignoring how quantum effects underpin the everyday world of commonsensical matter. (And, it hardly needs pointing out, while ignoring the rigorous math that underpins QM.)

But physicists haven't been averse to sensationalism, too. Several of the "fathers" of QM, Niels Bohr in particular, seemed to glory in a "subjective" view of QM (see, e.g., Wick, 1995, esp. Chs. 6 and 17). This predilection is a subject for the social scientists: perhaps the psychological reasons lie among the social ferment and loss of traditional certainties in Europe after the Great War. But it seems especially strange because when you dig into the math (and QM is quintessentially a *mathematical* theory) "mystical" and "subjective" are not adjectives you think of. "Austere," "mathematical," "rigorous," even "inhuman," maybe; but hardly "warm and fuzzy"! Edna Millay should be the lit'ry reaction, not Jean-Paul Sartre.

And after all, QM *does* describe the real world, and that has practical as well as philosophical implications. In fact, QM has been of considerable practical use for some time, as in solid-state physics (especially metals and semiconductors; see, Kittel, 1986, for example, a much-revised and now classic text). Quantum mechanics, moreover, will be-

*Of which I'm one, by the way.

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come even more intrusive as microelectronic devices continue to shrink. "Computational" chemistry, the prediction of the properties of molecules from QM first principles, has also become increasingly respectable in the last 20 years. Even the weirder aspects of QM are now seen to have potential technological applications.

And as for the ultimate shrinking in scale, there's molecular nanotechnology (which, by the way, is why I've had to dig into QM, after carefully avoiding it since my undergrad days).

So HHEs are getting involved with QM, for the best of reasons: it's *useful*, and it's getting more so.

Atoms, Molecules, and Matter

Matter is *digital*, and it's so because of quantum mechanics. Atoms come as well-defined units: all atoms (of the same isotope, anyway) are identical. Not just "really similar" or "pretty much alike" but *identical*. We loosely use "identical" in everyday speech, but it's exact in the nanorealm.

And this fundamental identity is why chemistry works, and fundamentally why matter is the way it is. It's also why molecular nanotechnology is conceivable. A major issue in macroscopic manufacturing is making sure your interchangeable parts actually interchange. And so, of course, a lot of effort and expense goes into ensuring that parts meet specs. But since atoms (and molecules) are intrinsically identical, this is one issue that is vastly simpler for nanotechnology than macrotechnology. As Eric Drexler, nanotechnology's preeminent theoretician, has put it, God has very good quality control on atoms.

In a "continuum" world, atoms of the same element (assuming there *were* atoms) would *not* be alike. The energies of individual atoms would all be a bit different, because there would be no physical law that said an orbiting electron could have just this energy, and no other. So electron orbits in different atoms would all be a bit different, and so different atoms *of the same element* would all have different sizes, different chemical reactivities, different energies . . . It passes reasonableness that chemical bonding, in anything like the form we see in our universe, could exist in such a "continuum" universe.

How does quantization come about? By the Schrödinger equation, as fundamental to twentieth century physics as Einstein's $E = mc^2$, though not so famous to the wider world:

$$\Sigma[-(h/4\pi m_j)\nabla j^2\Psi]+(2\pi)V\Psi=-i\,\partial/\partial t\,\Psi$$

Yeah, it's good for impressing your friends and confounding your enemies. Unlike Einstein's signature expression, Schrödinger's is a *differential*, rather than merely algebraic, equation, and that's probably hindered its wider fame. The impressive ∇^2 ("del-squared") sign and the curly d (∂) are differential operators, and the capital sigma (Σ) just means to sum over all particles, each having a mass *m*. And *h* is Planck's constant, the fundamental constant of quantum mechanics. Its value sets the "graininess" of the universe.

The "V" is a potential, which typically consists of just the electrostatic attractions and repulsions among the partiqle(s)*. And Ψ, the Greek letter "psi," is the famous *wave function*, the quantum mechanical entity that describes how the partiqles behave and where they're likely to be found.

Oh, and one other thing: "i" is the

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* *From now on, I'm going to follow the suggestion of Lévy-Leblond (1977) and refer to QM entities as "partiqles" to emphasize that they're neither particles nor waves. They can be electrons, photons, neutrons . . . anything that must be described quantum mechanically. Partiqles are different; they follow their own rules. But in some circumstances they kind of behave like a macroscopic particle or wave.*

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square root of negative one. So the Schrödinger equation is not merely differential, it is *complex*. But real, physical quantities are measured with real numbers. So we need a rule for going from the complex wavefunction to a measurable (or potentially measurable) quantity expressed with a real number. The rule is that you multiply Ψ by its "complex conjugate," Ψ^* (read "psi-star")[†]. This gives you a real-valued function, the so-called "amplitude-squared," and *that* tells you the probability of the partiqle's being found in a particular place at a particular time.

It's reasonably straightforward to solve the Schrödinger equation for the hydrogen atom (1 proton, 1 electron)[††], and when you do, you find that only specific energy levels are allowed. These, traditionally, are called "orbitals," from the idea that they're where the electron "orbits," as in all those fifties-era pictures of "The Atom in Your Future." But that's really not a very good picture. It's better to think of the orbitals as sort of "standing waves in space" where the electron might be found.

That's where the quantization comes from: solutions of the Schrödinger equation typically look like standing waves. It's easy to make standing waves: a sounding guitar or piano string is doing so. The string vibrates only at certain wavelengths because only waves with a half-wavelength that divides evenly into the length of string are stable. In a sense, energy levels in atoms are quantized—can have only certain values—for the same reason a vibrating string can sound only a certain pitch. And, after all, it's certainly intuitively reasonable that vibrating strings are quantized; when you strike middle C, you don't expect to hear a mishmash of pitches!

Furthermore, an atom is typically found in its lowest-energy state, the so-called "ground state." The higher energy levels aren't stable for much the same reason that a ball sitting on a slope is unstable. Like the ball, an electron in such an "excited" state tends to "roll downhill"—to lose energy—until it lands in the ground state.

And, of course, the ground states of all hydrogen atoms are exactly alike.

This explains spectroscopy, too, by the way. A nineteenth century physics conundrum was to understand why atoms are observed to emit radiation only at certain wavelengths. An early triumph of QM was to explain the patterns completely: an electron trickling back to the ground state gives off light whose wavelengths correspond to the energy differences between the orbitals.

Unfortunately, after completely solving the hydrogen atom, we have a problem. We can't solve the Schrödinger equation for even the next simplest atom, helium, with two electrons and two protons in the nucleus. The reason is purely mathematical. The two electrons repel each other, of course, and this additional repulsion term in the potential leads to insuperable mathematical difficulties.

This is nothing new or peculiar to QM: it's like the notorious "three-body problem" in Newtonian physics, where you can't explicitly solve the motions of even just three moving masses, even though you can completely solve the two-body case. But, just as with classical gravitation, you can use approximation techniques to sneak up on the answer.

One of the simplest, which goes back to Hartree in 1928, is to assume that an electron in a multi-electron atom moves in an "average potential" set by the protons plus all the other electrons. Such a system *can* be solved mathematically, if

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[†] *An inane techie joke from my undergrad days: a theatrical "Sigh!" would invariably elicit the response "Psi-star"!*

[††] *No, I'm not going to do it here. Check any text on quantum mechanics or quantum chemistry if you're interested, such as Karplus & Porter (1970).*

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tediously, and the orbitals you get turn out to be very similar to hydrogen-like orbitals, just with shifted energies. In turn, this fairly crude approach works astonishingly well. It explains the Periodic Table, for example. Elements' chemical properties, and the similarities among elements, depend on what orbitals ("shell") their outermost electrons occupy.

Actually, having said that, I must backtrack: each orbital can contain *two* electrons, so you fill each hydrogen-like orbital a pair at a time. So, for example, *both* electrons in a helium atom are in the lowest hydrogen-like orbital, the so-called *1s* orbital, and the large energy gap up to the next orbital, the "*2s*" orbital, accounts for helium's chemical inertness. The reason that orbitals fill pairwise is that electrons have another property called "spin," and an orbital can accommodate two electrons so long as they have opposite spins.

Thus, each electron in an atom has a unique state: if they're not in different orbitals, then they must have opposite spins. This is because electrons are partiqles called "fermions" (named after Enrico Fermi), which must be in different states. (This is called the Pauli exclusion principle, by the way, after another QM pioneer.)

One of the mathematical rules of a wavefunction is that it must give the same results when two partiqles of the same type are interchanged. Fermions have wavefunctions that change sign on such interchange, while other partiqles (called *bosons*) don't. (Since you multiply the wavefunction by its conjugate to get the probability amplitude, which determines what you can actually measure, the sign of the wavefunction itself doesn't matter.) Given this change in sign, it's then straightforward mathematically to show that fermions must exist in different quantum-mechanical states*.

* *No, I won't do that here, either. See Eisberg (1961), for example.*

At present there is no widely accepted theoretical explanation for why some partiqles are fermions while others are bosons. It's just an experimental fact, although evidently a goal of theories like "broken supersymmetry" is to explain it.

Computational Chemistry

What's a molecule? A reasonably stable arrangement of atoms hooked ("bonded") to each other. And chemists routinely talk about (say) the "carbon-hydrogen" bond, or the "oxygen-silicon" bond. Of course, there's also an enormous body of empirical chemical knowledge describing *how* atoms bond to one another, such as the concept of valence, an atom's combining capacity. In turn, you can rationalize valence as the "sharing of electrons" or "the rule of octets," the idea that compounds are trying to reach a "stable shell" of eight outer electrons.

But though they are useful concepts, and find much space even in modern textbooks, these simplifications fundamentally just aren't correct. A molecule is basically a quantum-mechanical entity, a local minimum-energy solution of a many-body Schrödinger equation. It's a three-dimensional arrangement of positive partiqles (nuclei) held together by a cloud of negative partiqles (electrons) buzzing around them. The electrons are localized in particular places (which are *also* called "orbitals"), and in a stable molecule these orbitals are arranged such that the electrons in them screen the positive charges of the nuclei from each other. So the whole business fundamentally sticks together by electrostatic attraction, with QM determining where the charges can be located. (By the way, a theorem from classical electrostatics showed that no static arrangement of electric charges that are free to move can be stable. QM solved *that* conundrum, too; the rules of QM effectively "fasten" the charges in place.)

It's reasonably easy to set up the

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Schrödinger equation for a simple molecule; methane (CH^4), say. So why do we still have empirical chemistry? If all chemistry results merely from solving Schrödinger equations, why do chemical texts still tabulate pages and pages of empirical facts based on man-millennia of experimental effort? As a chemist friend of mine put it years ago, it's because the math gets *much* too hairy. Those Schrödinger equations are *far* too difficult to solve directly. In fact, the Schrödinger equation can be solved explicitly for only the very simplest molecule, the hydrogen molecule ion (H_2^+), which consists of two protons held together by a single electron. (It's also pretty unstable, so it's hard to get experimental data, but the data that have been gotten agree completely with the QM calculation.)

Of course, there are useful approximations. For one thing, only the outer ("valence") electrons participate in bonding to any great degree; the orbitals that the inner electrons occupy are essentially the same as those in the isolated atom. So, we really only need to model the valence electron orbitals.

A classic approach is to assume each atom starts with its valence electrons in the hydrogen-like orbitals of the Hartree theory, and then to combine these orbitals mathematically to get the molecular orbitals. Even crude versions of this "molecular orbital" theory give useful, albeit semi-quantitative, models. Organic chemists especially have been able to use them to understand, for example, the valence electron states in molecules like benzene ("Hückel's rule"), or to rationalize why certain reactions occur while others don't because of the symmetry of the orbitals between bumping molecules (the "Woodward-Hoffman" rules). But till recently, achieving *quantitative* agreement with experiments, for all but the simplest molecules, was of limited relevance in the real world, simply because the computational costs were prohibitive.

This is changing. Over the last two decades, "computational chemistry" has become of growing importance. The reason, of course, is the astonishing plunge in computing costs over the last few decades. For such *ab initio* ("from the beginning") studies, all you need is the Schrödinger equation, the fundamental constants (Planck's constant, the charge and mass of electron, and so forth), and a *big* computer. Then the properties of real molecules drop out, just by brute-force calculations through successive approximation. (You can model many-electron atoms in detail this way, too.)

Of course, it doesn't work perfectly. You need some mathematical tricks to expedite the calculations, many of whose names read like a Who's Who of the early days of QM: the "Born-Oppenheimer" approximation, "Slater"-type orbitals, the "Hartree-Fock" approximation, etc. But they work remarkably well. You can now even buy one of the popular *ab initio* program packages, GAUSSIAN, for a Pentium-based system. (Yes, folks . . . you *can* try this at home!)

At last, we have some prospect of *explaining* those manifold empirical chemical facts, all from first principles.

Uncertainty

"We never experiment with just one electron or atom . . . any more than we can raise Ichthyosauria in the zoo."

—Erwin Schrödinger, 1952

Molecules, like the atoms that make them up, are digital. They have well-defined shapes and sizes, and again, like atoms, are all alike. And all because of quantum mechanics. The concept of molecules as identical building blocks is especially important if you're thinking about nanotechnology.

But you're probably now worrying about that uncertainty principle. How can we talk about molecules' having a "shape," when the nanoworld is so fuzzy?

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But the uncertainty principle puts stringent limits on how fuzzy things are. Basically, the more massive, the less fuzzy. Tiny, light electrons are squirrelly indeed. But atoms, being much more massive, are almost classical objects. This has been brought home forcefully by recent high-quality scanning-tunneling microscope (STM) images, in which you can see individual atoms in individual molecules. They're lined up like little overlapping balls looking for all the world like the space-filling models in chem class. (And so yes, Schrödinger was wrong in his assertion above.)

It's also worth pointing out that *everything's* not governed by the uncertainty principle, not even in QM. Partiqle masses, for example; you can measure an electron's mass arbitrarily precisely. Just as in classical physics, it all depends on how clever an experimentalist you are. Similarly for electric charge. The charge of an electron is both completely fixed and (in principle) completely measurable. If the electronic charge changed at all, atoms and molecules would change in their energies and sizes, because, of course, the electrostatic attractions and repulsions determining them would change. That isn't observed.

Nanoscale? Not!

Quantum phenomena are not necessarily nanoscale, either, even without getting into the intricacies of chemical bonding. Quite a number of embarrassments of 19th-century physics were solved by QM. I've already mentioned spectroscopy. The heat capacities of gases and metals are another.

Polyatomic gases don't have as large a heat capacity as classical physics predicts. According to classical physics, molecules made of more than one atom should be able to vibrate arbitrarily, just as though little springs connected the atoms, and that vibration should soak up some of the heat applied. (This problem was noted by Maxwell as early as 1859!) The QM explanation is that the vibrations are quantized, so that the atoms are *not* able to vibrate arbitrarily.

A similar problem appeared with metals by the late 1890s, after the discovery of the electron. Physicists rapidly realized that moving electrons probably accounted for electrical conduction in metals. Only, if that were the case, the electrons couldn't be contributing to the heat capacity—in utter defiance of classical physics, for if an electron could move under an electric field, "surely" it could acquire heat energy, too. Again, QM saved the day: because electrons are fermions, they can't occupy the same state. So, each of the 10^{24} or so conduction electrons in a lab-sized chunk of metal is in its very own quantum state—in one of a staggering number of "orbitals," if you will, formed by blending all the atomic orbitals from all the individual metal atoms. Only the relative handful of electrons near the boundary between filled and unfilled orbitals—near the so-called "Fermi level"—can acquire heat energy, because they're the only ones that have a higher-energy state they can move into.

Ferromagnetism, the magnetism shown by an ordinary bar magnet, is another quantum-mechanical phenomenon. Elementary science texts tell you that the magnetism comes from unpaired electron spins, because a piece of iron acts "as though" an extremely intense internal magnetic field is forcing the electrons (well, some of the electrons, anyway) to line up. That's true, but what the elementary accounts usually don't tell you is that the lining-up is fundamentally quantum-mechanical in nature. There *is* no "intense internal field" in an iron crystal; but in iron and a handful of other substances, the minimum-energy configuration dictated by the Schrödinger equation puts unpaired electrons into orbitals.

The most famous classical conundrum was the "ultraviolet catastrophe." Classical physics *cannot* explain even

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something so simple as the radiation of energy off a hot stove burner. All calculations invariably predicted that *all* wavelengths, even very short ones such as ultraviolet or (after they were discovered) X-rays, should be emitted by a hot object. But, since you don't burn out your eyes with X-rays when looking at a glowing stove, it was obvious something was profoundly wrong. In fact, it was just this problem that led to the first quantum theory, which Planck proposed in 1901.

You sometimes hear that by the end of the 19th century physicists were complacent that they'd just about explained everything. Maybe some of the second-string players thought that, but the varsity were well aware that something was seriously wrong in the foundations of physics.

Quantum Solitaire and Physical Reality

One of the many ways I waste time on my computer is by playing one of those computer solitaire games. (At least it's among the more enjoyable ways.) I see a field of overlapping cards, face down, and I click the mouse on the card I want to turn over.

Now, I tend to assume that the value of unturned cards is definite, even before I turn them over. If I see an ace of spades when I click with the mouse, I assume it was an ace of spades in its unturned state. For, after all, that's how real, physical cards work.

And yet we can see how that need not be the case for computer cards. Sure, it's probably true, because it would be easiest to program it that way. But it's easy to imagine how a programmer might make the values of the unturned cards uncertain, say by choosing a number from a random-number generator when I click the mouse. An example would be to have a 1/40 chance of drawing the ace of spades, if 40 cards are still unturned and if the ace of spades hasn't been drawn already.

The programmer could even get fancier without too much trouble. She could program the game so that the probabilities of different cards change depending on some other factors; say, the direction from which the mouse pointer is approaching, or the speed the mouse is traveling. Maybe the chances of drawing the ace of spades decrease the faster the mouse is moving, or if the pointer is approaching from the left.

Such a "quantum solitaire" game captures much of the weirdness of quantum mechanics. First, what you get can only be expressed as a probability. This, of course, doesn't mean *anything's* possible; you won't draw a joker from a 52-card deck! But you can't say for sure *which* card you'll draw; you can only state probabilities. In some sense, *all* possibilities coexist before you make your choice—what in QM is called a "superposition of states."

Second, the probabilities depend on how you interact with the system. What you get depends on what you do. This is fundamentally the origin of the famous "wave-particle" duality, for example. Electrons under certain circumstances will act like waves; but under others they will act like (classical) particles.

So, is there nothing "out there" until you measure it? Hardly. Because what you get from a QM system depends on how you poke it doesn't mean nothing's there until you poke! And it certainly doesn't mean you can get *anything*! The quantum system exists, objectively and externally, but we can't deal with it in its pure form. When we touch it, it resolves into one or another out of a set of values it could have—what Shimony (1989) calls an "actualization of potentialities."

"Against 'Measurement'"

The title of this section is that of the last paper the late John Bell ever published (Bell, 1990). He was a crusader against quantum mysticism—though, as

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we'll see, he obtained a result that underscores just how weird QM is.

But Bell particularly objected to the widespread notion that "measuring" a QM system must involve "consciousness" or "knowledge" or "observers" or some such metaphysics. Surely the "poking" (as I've described it above) that resolves a QM system into something experimentally observable is a straightforward physical process. Indeed, the HHEs who are getting into QM tend to speak of "interactions" or some such word that avoids the semantic burden of "measurement."

But this still begs the question. If "measurement"/"interaction"/"poking" is a physical process, *what* is it? There actually seems to be an emerging party line on this matter, which I'll return to later.

Albert Einstein, John Bell, and You

But first, let's look at the quantum solitaire game again. Say I have two cards remaining face down, and I know that only the king of hearts and six of clubs haven't been played. So, I *know*, when I turn one card over and see the king of hearts, that the other card's the six of clubs. This is a simple example of "entanglement"; the states of the cards are "correlated." A simple, real QM example is the spins of electrons in a helium atom. They must be opposite; so if one is up, the other is down; if one is left, the other right; and so on.

Now, if the cards are truly indeterminate till played, some mechanism in the program must ensure that only the other, unplayed card can appear. Similarly, in a helium atom one electron must "know" what the spin of the other is. Perhaps, in something as tiny as a helium atom, this isn't too surprising. The problem gets worse, though, for correlated spins on partiqles *flying apart*. Nothing in the rules of QM states that partiqles with correlated states have to stay in close proximity, and there are a number of ways to make a pair of entangled partiqles flying apart. So then does QM imply that when one partiqle is finally "measured," the other partiqle "knows" and flips its spin accordingly, even though it might then be light-years away? Wouldn't it be simpler to say that the spins had some value that's merely unknown till it was measured?

This was the essence of Einstein's objection to QM, which was written up in a now-famous paper in the mid-30s. It's called the EPR paradox, from Einstein and his two younger co-authors, Podolsky and Rosen.

John Bell, in a classic paper in 1964, showed why the spins couldn't have been simply unknown before the measurement. To see why, we have to consider further measurements on the spins. (To make discussion easier, we'll speak of the directions as NORTH-SOUTH/EAST-WEST rather than UP-DOWN/RIGHT-LEFT).

Once we resolve the spin of one partiqle, say as NORTH, then further measurements along the north-south direction will always show its spin as NORTH, with 100% probability. However, its spin at right angles is now completely indeterminate; a horizontal measurement will yield EAST or WEST with 50-50 probability.

Bell's insight was to consider results at intermediate angles. If we measure along a 45° northeast-southwest line, for example, a NORTH partiqle has (as seems intuitively reasonable) a larger chance of being NORTHEAST than SOUTHWEST. Bell then showed, using only simple algebra, that the QM predictions for the intermediate angles weren't consistent with the partiqle's having *any* well-defined spin direction beforehand. It's now been experimentally shown that these "Bell inequalities" are violated: Nature follows the rules of quantum mechanics.

It sure *seems* that, when one partiqle's measured, "something" "reaches out" and tweaks the other partiqle so it's

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opposite. Furthermore, although it's apparently not possible to use these nonlocal correlations to send messages faster than light, they certainly violate the spirit, if not the letter, of relativity.

Einstein would not have been pleased.

Killing Schrödinger's Cat

Now let's go back to that measurement problem. In classical QM (if that's not an oxymoron) a "measurement" is deemed to have occurred when the system has interacted with a "classical apparatus" to yield a definite result. At this point the system has resolved into one of its possible "observables."

And here we see a problem. For after all, if QM is truly the fundamental theory of nature, a "classical" apparatus is also quantum mechanical. It's made of atoms too. So, where does it end? *Analog* readers have no doubt heard of Schrödinger's famous tongue-in-cheek thought experiment, in which a cat is locked in a sealed box with a poison triggered by the (random quantum-mechanical) decay of a radioisotope. Is the cat then in a bizarre "alive/dead" superposition of states until someone opens the box to make a measurement? It's not always realized that Schrödinger was drawing a *reductio ad absurdum* here, to illustrate how preposterous the notion of a "superposition of states" is for a macroscopic object. (I, for one, had always wondered what the *cat* thought.)

For "alive" and "dead" are not quantum mechanical states! They're much too complicated. There are staggering numbers of individual quantum states corresponding to "alive," and an even more staggering number corresponding to "dead."

Evidently, then, there's something to the notion, after all, that quantum effects are less obtrusive on the macroscale. The emerging idea is that interaction of a quantum-mechanical system with a macroscopic, albeit also quantum-mechanical, system causes a "measurement"—a resolution into a particular state—by a process called "decoherence." There are so many different partiqles in the macroscopic system, all with different amplitudes and wavelengths and phases, that coherence can't be maintained, and the quantum system collapses into an observable, on an immeasurably short timescale.

But what's a big enough system to be "macroscopic"? It's fuzzy; there is no hard and fast division, and in fact, in a remarkable set of experiments a group of physicists (Brune et al., 1996) has actually measured decoherence—a "measurement"—occurring in real time. They prepared rubidium atoms in an entangled state, and for a "measurement device" (which they call a "Schrödinger cat"(!)) used a cavity containing none or a few microwave photons. Since so few partiqles were involved, the decoherence could be "caught in the act," over timescales of a millisecond or so.

An intriguing and elegant idea is that decoherence results from much the same "laws of large numbers" as does statistical mechanics. How big does a molecular system have to be before we have to use statistics to describe it, rather than mechanistic laws dealing with individual bumping molecules? That point is also fuzzy and in some dispute. By implication, then, the familiar, realistic macroscopic world emerges from the quantum world in much the same way as thermodynamic concepts like "heat" or "entropy" emerge from large ensembles of (classical) particles. Both are the consequences of kazillions of individual interactions at the nanoscale. This notion has been explored in a popular book by Lindley (1996), if you're interested.

All this said, Bell was suspicious of decoherence. As he says (Bell, 1990), "Surely it would be possible to find a sum of very many terms, with different amplitudes and phases, which is *not* zero?" (Emphasis mine.)

He was onto something, as we'll see in the next section.

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Quantum Technology

Maxwell's equations*, so far as we can tell, describe completely all of electricity and magnetism, from the propagation of light to the generators at Hoover Dam, from the flash of a lightning bolt to the computer on my desktop, from the static on scuffling across a carpet to the motor running an air conditioner, from the stereo system I'm listening to now to the FM transmitter that's broadcasting the music.

Quite a contrast! If we were familiar only with the natural manifestations of Maxwell's laws, we'd hardly predict its vast array of technological applications. It's a long way from a lightning bolt to a stereo. Even something as commonplace as a continuous electric current is rare in the natural world, much less things like computers, motors, and cassette tape players.

Of course, it's easy to see why: the technological applications of Maxwell's laws require extremely intricate arrangements of matter, arrangements that simply don't occur in nature. We can think of technology, then, as actualizing potentials of physical laws, potentials that perhaps haven't even occurred in the Universe previously—and whose depth is utterly astonishing.

I suspect we're now in much the same position of exploiting QM as was the late nineteenth century with electromagnetism. I mentioned in passing the great success of QM in the practical applications of solid-state physics, semiconductors in particular. Already certain electronic devices, such as the tunnel diode (which exploits the spatially extended nature of the wavefunction) rely explicitly on QM effects. By and large, though, conventional electricity, including electronics, is still at large enough scales to ignore QM. Even with your computer, you could think of switching an "electrical fluid" and not be far wrong, at least as long as you don't dig very deeply into the semiconductor "switches" themselves.

As we all know, though, microelectronic scales continue to shrink, and the quantum domain approaches. Soon enough, those eighteenth century intuitions just won't work any more and new engineering will be needed. Using individual electrons is an engineering goal, one that will require QM to realize.

"One electron-one bit" really is pretty humdrum stuff, though. The "weird" rules of QM surely hold as much promise for technological exploitation as those of electricity and magnetism. As we all know, we don't encounter quantum superposition in everyday life, which is one reason QM is so counter-intuitive. The reason is that macroscopic superposed systems are *fragile*. They require extraordinarily painstaking arrangements of matter, and so don't occur for much the same reason as we don't find generators or electronic computers lying around.

But quantum superposition has some astounding technological possibilities, especially in information processing (Spiller, 1996; *Physics World*, 3/98). One is the quantum computer. Ordinary von Neumann computers, of course, work with bits: zero/one; on/off; up/down, and a bit is either one thing or another. But quantum systems, as we've seen, can be in bizarre intermediate states that have no macroscopic equivalent, with all possible observable values somehow coexisting until resolved into one definite "measurement." This has led to the notion of the quantum bit, or "qubit": a bit that is simultaneously zero *and* one; on *and* off. Intuitively, it seems such a quantum computer could make feasible an extremely powerful sort of "parallel processing," in which the superimposed quantum states could rapidly explore a vast number of alternatives, until finally resolved into a single answer or result or whatever. These intuitions have been re-

* *Don't worry, I won't write them out. One ∇ sign per article is plenty!*

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cently confirmed theoretically (Chuang et al., 1995; Shor, 1997); in particular, it's been shown that a quantum computer could factor a number in "polynomial time," vastly shorter than the exponential times of conventional algorithms. As many modern cryptography schemes rely on multiplying two very large prime numbers together, because at present it's extremely difficult to factor large numbers, a quick factoring algorithm would be of more than academic interest!

As if to compensate for compromising conventional cryptography, quantum technology makes another sort conceivable. This would involve using partiqles in entangled states (Bennett, 1992). A classic problem in sending secret messages is detecting eavesdroppers. Because entangled states are so fragile, though, no eavesdropper could read your message without your knowing it. Attempting to intercept the quantumly encoded message would destroy it.

Note the interesting shift in perspective in these proposals. Far from considering a quantum system some sort of unreal "superposition of states," one of which "acquires reality" by "measurement," the HHEs are treating the system as a perfectly real, if extraordinarily fragile, entity with useful properties. It's then a matter of engineering to ensure this entity gets protected until it can do its job. The whole approach reminds me of a chemical engineer trying to deal with an extremely reactive compound. He needs lots of engineering to prevent the compound from being destroyed by unwanted reactions before it arrives at its desired use.

As you've guessed, though, no one has any idea how to build devices that would be robust enough to work in the real world—especially for a quantum computer, which would involve preserving the fragile quantum states over the extended course of the computation. Decoherence is so *easy*. (Though, as Bell implied, it need not be inevitable.) I suspect that here lies another application of molecular nanotechnology, as it's likely to require atomistic control to build devices that are precise enough and clean enough to preserve the quantum states.

To conclude this section on another nanotech note: it's interesting the degree to which serious writings on nanotechnological designs deal with atoms classically, more or less as sticky little billiard balls. Sure, it's easy and intuitive, and the uncertainty principle lets you get away with it in most cases. But quantum effects are much more accessible at the molecular level, and counterintuitive though they be, they could be quite useful. I suspect that real nanotech devices, whenever they might arrive, will not ignore them.

QM vs. GR

Curses on the nanny universe! You can't go faster than light, you can't know a partiqle's position and velocity arbitrarily closely, you can't do this, you can't do that. . . .

It's little wonder that QM and (especially) general relativity (GR) haven't been very popular with SF writers and fans. The lightspeed limit is especially exasperating for those of us who like to imagine traveling to distant suns in a fraction of a lifetime, *without* exiling ourselves from the world we left, which otherwise ages inexorably while we remain relativistically young. It's little wonder there's a lot of looking, with varying degrees of seriousness, for ways around the lightspeed limit, and a literature (mostly of dubious quality) on nonrelativistic physics.

Unfortunately, it's unlikely that a clause in fine print allowing FTL will be discovered in the macroscopic realm—GR is *very* successful at describing the macroscopic world. However, GR is (surprisingly) a classical theory, and at its base is fundamentally incompatible with QM. And we've seen how correlated partiqles, though they may not allow FTL messages, suggest an "action at a

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distance" that profoundly conflicts with the spirit of relativity (and that Einstein abhorred).

Relativity isn't *completely* dissonant, to be sure. When you incorporate *special* relativity with QM, the electron spin, which is otherwise totally *ad hoc*, emerges naturally. Dirac showed this in the late twenties, by the way, so it's nothing new. In fact, if we were to carry out truly *ab initio* calculations of atoms and molecules, we would use Dirac's equations, not Schrödinger's. However, they're mathematically even less tractable (!).

There have even been some limited successes in marrying GR and QM; Stephen Hawking's celebrated discovery that black holes evaporate is one such. But that's an *ad hoc* patch, really. It remains embarrassing that the two most fundamental and successful physical theories of modern times are so deeply, deeply incompatible. If you're looking for FTL, your best possibility probably lies in some resolution of this incompatibility.

Personally, I get a sense of a "mechanism" behind the universe, a whole set of machinery inaccessible to us. We're dealing at the level of the virtual cards on the computer screen, while the workings of the computer behind remain out of reach.

Can it be made accessible? I have no idea. It's probably a grossly naïve notion anyway. But recall those minor embarrassments in the comfortable structure of late nineteenth century physics that led to the revolution of the quantum theory itself. ■

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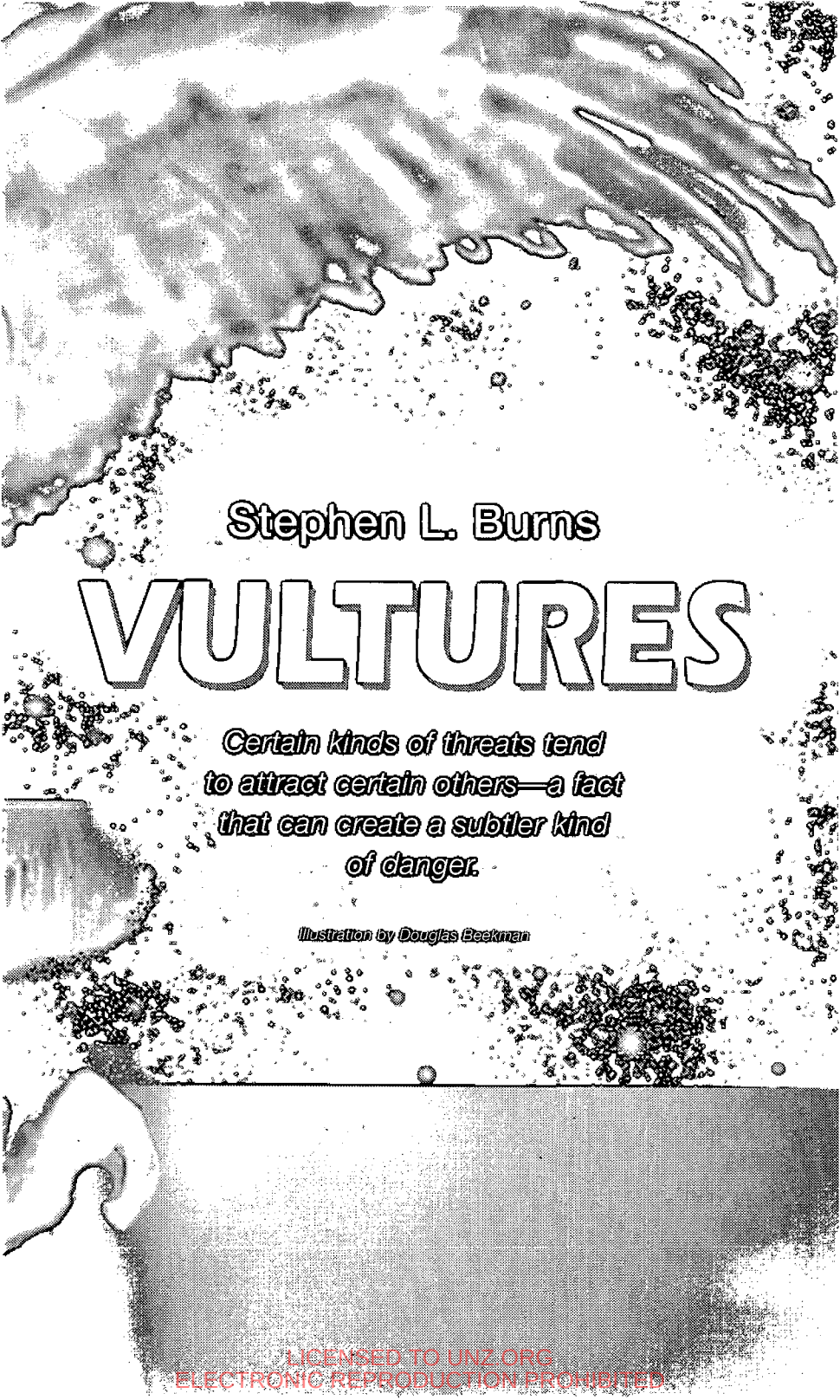

Stephen L. Burns

VULTURES

Certain kinds of threats tend to attract certain others—a fact that can create a subtler kind of danger.

Illustration by Douglas Beekman

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Vultures, Hugh Longworth thought sourly as he turned a weary warning scowl on the panhandler buckbumming him as he tried to get into the cab. They're *everywhere.*

He was beyond tired, and *god* how he hurt. The plane ride had been pure misery. The stews had treated him like a leper. The old prune in the next seat had all but beaten him over the head with her Bible in her attempts to instruct him in the error of his ways. The smell of the inflight lunch had nearly driven him to spend the rest of the trip in the head, writing a Ralph Report in quadruplicate—which actually might have been more pleasant than old pucker-mouth's brain-damaged pronouncements.

Now *this.* He was tempted, really tempted, to reach into his bag, haul out his piece, jam it up under the glomrat's stubbly chin, and suggest that he get out of his face and go find a new venue, posthaste. Maybe go get his worthless ass run over trying to wash the windshields of passing semis on the freeway.

But he was keeping a low profile. Very soon far bigger game would be in his crosshairs.

Besides, he still had enough of his old mojo working for the look on his face—and the face that look was on—to send the gimme scuttling away.

"Where to, buddy?" the cabbie asked as he climbed into the back of the battered yellow Chevy Duodyne and slammed the door. A mid-twenties Latino woman with an orange fuzzcut and tweed mac—she was plenty pretty enough to be a model or starlet. *Welcome to California.*

"78893 Ponderosa Pine Road," he answered gruffly, aware of her dark eyes on him in the rear view mirror. "You know where that is?"

"Sure do." She slapped the flag down and started the hack rolling, the electric motors a muted hum. "Might as well get comfy back there. It's a long ride."

Hugh intended to. Once his seatbelt was buckled he fished a cigarette out of his sport coat pocket, and pointedly ignoring the NO SMOKING sign riveted to the seat back, lit up. That first reviving puff came out in a long sigh. After two more restorative hits he opened his eyes and looked up, meeting the cabbie's gaze in the rear view.

There was the expected disapproval on her oval face, but she surprised him by buzzing his window down a notch and saying with a shrug, "Well, at least you're not into cigars."

"Actually I am," he answered tonelessly. "I just needed one of these worse."

A knowing nod. "Been there myself. Quitting was a real bitch. Still, I did start feeling better. I run five miles a day now."

Hugh wasn't in any mood for pious health tips. He took another long pull, let it out. Smiled a death's head grin. "Does it look like quitting's gonna make any difference to me?"

She inspected him in the mirror, taking in his skeletal, emaciated frame, hollow cheeks, sunken eyes, sallow skin marked with the ugly purplish lesions of Kaposi's sarcoma. Much to his surprise her face remained placid, untroubled.

"You never know, man, it might," she answered at last. "What with where you're going and all."

Hugh swallowed a sarcastic reply. Her remark suggested that she knew something about his destination. A little extra intel gathering ahead of time might prove helpful, although he doubted it. Playing buzzard bait took the sort of chops exhibited by a pig carcass used to troll for sharks.

"So you know this Doctor Blackfeather?"

"Know of him. I've taken a few fares out there, brought a couple back."

He took another puff, working up the right tone of voice. "Do you think he's, you know, for real?" He hit it on the money, sounding nervous and cautiously hopeful.

The cabbie shifted over to alky. The

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cab surged forward, whipped around a ramp, and driving one-handed she effortlessly plugged them in what looked like a bicycle-sized hole in the traffic blowing along the westbound freeway at over seventy per. After a moment he was able to get his fingers pried loose from the upholstery.

"Does it matter what I think? You're the one going to see him."

Hugh crushed out his butt. "Don't tell me, let me guess. You're a psych student."

She laughed. "How'd you guess?"

"I must be frigging psychic." He was too tired for this shit, and it was pointless anyway. So he closed his eyes and settled back, hoping to grab some sort of recharge before he began the hunt. At this point even tying his shoes exhausted him. Banter might as well be a biathlon.

The motion of the cab far more relaxing than that of the plane, he dozed off and dreamed of the bygone times when he too used to run five miles a day, and ride in the occasional bicycle race. Back before a gutshot junkie's blood had washed over the road rash collected from a fall off his bike, putting him on the fast track to a funeral before he'd see forty-five.

"Wake up, mister. We're here."

Hugh came to with a jerk, momentarily disoriented.

The cab had stopped moving. The cabbie was standing by the rear door, holding it open for him. *Blackfeather. Right.* He groaned, fumbled with the seatbelt. As he began to get out the woman offered her hand to help him.

"I can do it myself," he snapped. Problem was, he couldn't put his money where his mouth was. When he tried to stand his legs went wubbulous, and if she hadn't grabbed his arm he would have gone down. She steadied him a moment, then when he seemed to have his failing body back under control again, stepped back.

"Thanks," he growled, angry and embarrassed.

"We all need a little help sometimes. Give some, get some back. It all balances out."

He stared at her. "I'm *dying*, lady. Nobody can help me, and anybody bad off enough to need my help is in deep shit."

"You're wrong. As long as we've got breath in our lungs we can give help and accept it, and where there's help there's hope."

"You should write a fucking song," he replied to her cheerful brainless platitude. He'd proved time and again that hope was a ticket to ride down a dead-end street of bankruptcy and despair. He reached for his money. "How much I owe you?"

She shook her head. "*Nada*. The California Gay and Lesbian Support Network will pick up the tab."

Hugh's scowl darkened. "Who said I was gay?"

"Doesn't matter. I'm a member, and a friend of mine who is also a member set up a fund to cover the cost of anyone coming out to visit Doctor Blackfeather. I've gotten pretty good at picking them out of the crowd."

"I pay my own way."

"Sorry. Like I said, we've got you covered."

"Fine," he said, hauling out his flashroll and extracting a hundred from the middle. "Then consider this a tip."

She shrugged and took the bill. "I'll consider it a donation. Thanks for your help."

"Fatten your frigging shill fund some other way," he spat, snatching the bill back, tearing it into shreds and letting the pieces flutter to the ground.

Well, there went a good chunk of his cover. Tough shit. He reached into the cab and extracted his bag. When he turned back she was still standing there, staring at him. Her big dark eyes were sad, and her full lower lip was caught in her teeth.

Pity pushed more of his buttons. Fact

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was, just about everything did these days.

"You got something more to say?" he demanded.

"Nothing you can hear right now." She reached into her shirt pocket, extracted a business card, tucked it in the breast pocket of his coat. "Tell you what. Give me a call when you want a ride back. Maybe you'll be feeling more charitable then."

"Thank you Doctor Feelgood." He slammed the cab door. "I'll make an appointment with your secretary."

"You're welcome." She touched the brim of her mac in salute, then got back in the cab and drove away.

He watched her go, perversely pleased that she'd pissed him off. Anger was about the only fuel left in his tank these days. He was probably gassed up enough for the work ahead.

The address he'd been brought to proved to be a fairly large compound surrounded by high stone walls. It was on a hilltop way out in a relatively undeveloped area, well over thirty miles from the airport, according to the maprom he'd consulted on the plane. The view was probably pretty good, but the main thing he noticed was how damn hot it was. The early afternoon heat pressed down relentlessly, squeezing what little energy he had left out of his bones.

He had to get moving before he melted. He slung the strap of his bag over his shoulder, then shuffled to the wrought iron gate. Mounted on the stone wall beside the gate was a call box, above it a modest brass plaque reading *Dr. George Blackfeather.*

This low key approach was a change from some of the places he'd been. Places where they'd done everything short of hanging up neon signs to dazzle the suckers. Check that, one clip-joint clinic did have a neon sign, the one run by the woman who called herself Madame Nightingale. Singing behind bars now.

He pressed the bar on the callbox, sweat dripping down his side when he lifted his arm. Lit another cigarette and waited.

A wispy girlish voice issued from the box half a minute later. "Yes, who is it?"

"Hugh Longworth. I have an appointment."

"Sure. Come straight up the drive to the main house. You want me to come get you?"

"I can walk." Brave talk, but he hoped it was a short hike. A ride would be great, but he wanted to case the joint a little.

"OK, George has been expecting you."

I just bet he has, Hugh thought with dour amusement as the lock clunked and the gates swung open before him. Waiting for that fresh meat to walk in the door. Little did he know that this time he was biting off more than he could chew.

Just let me bag one more vulture, he thought, taking a puff and gathering his resources. That'd been his mantra for the past couple months, his silent bargain with God. He knew he didn't have many hunts left in him. This one could well be his last.

He hoped not. The only thing keeping him alive was the bitter urge to take down as many TRAIDS quacks as he could before he cashed out. Having one almost within his sights was enough reason to grind his cigarette underfoot and start moving, rather than lying down and dying right then and there.

Inside the compound walls the first two things he noticed were what a beautiful job someone had done landscaping the grounds, and how bad the place smelled. The flowering plants, shrubs and trees exuded a sweet and heady perfume, but as strong as that fragrance was, it could not quite mask this other thick insinuating stench. The smell of rot and decay, the reek of an

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OD locked in a room a couple weeks past his expiration date.

The heat bore down on him as he struggled up the drive toward the big stucco house at its end. He'd covered perhaps a third of the distance when he learned what it was that stank so badly. Maybe twenty feet off the driveway, just past an orange tree laden with fruit—something he'd only ever seen in commercials—were the flyblown remains of some creature. He froze, his first thought that it might be what was left of a former patient. But the shape of skull and size of the bones told him it had been either a horse or cow.

The bad meat wasn't what kept his hackles up and made his gut clench. Crouched over the carcass, naked heads dripping with gore, were eight buzzards doing lunch on the remains. They looked up and met his shocked gaze, fathomless eyes seeming to check him out as a possible dessert.

His gorge rising in his throat, he swallowed hard and started walking again, faster than before. His hand strayed to his watch, hovering over the hidden panic button which would bring ten tons of law down on the place like a big blue shithammer. He rehearsed his moves in his head. Yell for help, dig his .38 out of its concealed compartment, try to make his six shots count.

He watched the buzzards warily, and they eyed him like a walking snack food ad. Just before he passed out of sight they returned to their feeding, probably deciding he wasn't ripe yet.

The predatory parasites he ran to ground on these hunting trips tended to come from two major species: the High-Technoids and the Mumbo-Jumbozos. Both used a similar MO, a mix of theatrical flash and well-rehearsed bafflegab designed to boggle and placate the prospective mark.

George Blackfeather—who was at least a real doctor, even if it was only of Veterinary Medicine—didn't immediately slot into either category. When he met Hugh at the door he wasn't all costumed up like a hospital drama doctor or decked out in ersatz shaman's threads.

Hugh found himself looking up at a tall, solidly built, late-fortyish Amerind dressed in jeans, a faded Bob Marley t-shirt, and battered sneakers with no socks. A long jet black braided ponytail curled over one broad shoulder and hung nearly to his belt. His lean, rough-hewn face broke into a big sunny smile when he saw Hugh.

"Hey, glad you made it," he said, offering a large brown hand. "Come on in."

"Thanks," Hugh answered, ignoring the hand and wasting no time in taking him up on his invitation to escape the broiling sun for the cool shady confines of the rambling Spanish style hacienda. At this point he would have gone unarmed into a stonk-house if it had air conditioning.

"Hope you had a good flight," Blackfeather said as he closed the door.

Hugh grimaced and wiped his sweaty face with his sleeve. "Not really."

"Sorry to hear that. We'll try to make your stay here as pleasant as we can." He gestured toward the rear of the house. "Come on, let's go find a place to park so we can get started."

Showtime. Hugh plodded wearily after him.

Instead of a movie-set examining room or phony lab full of bogus equipment, Blackfeather led him to a cool, comfortably shady glassed-in room looking out on a scattering of gardens, a half dozen outbuildings of various size, and several animal pens. Inside a small white-fenced corral a reddish-brown horse cropped the grass under the spreading branches of a tree, taking cover from the sun. Two cats prowled by a tin lean-to, and a big black dog was sacked out in the middle of one flower bed. Although Hugh had never seen a

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Vet's back yard before, he guessed this was about what you'd expect.

As his host seated them in comfortable wicker chairs, a short woman with a bleached blond shag hairdo entered through the arched doorway at the far end of the room. Barefoot, and one ankle ringed by chains and bells, her fairly wide hips were squeezed into tight red shorts, and disproportionally large breasts filled a pink knit tube top to the point of blowout.

Can you say bimbo? Hugh thought, taking a wild stab at what her function was around the place.

"Can I get you anything, George?" she asked in the thin, wispy, little-girl voice he'd heard through the callbox. Hugh found himself staring, and not at her braless thirty-eight C's. Her skin had an odd mottling, patches of it shinier and pinker than others. She remained oblivious to his scrutiny. Her attention was focused on Blackfeather, and there was no mistaking the worshipful gleam in her eyes.

"I believe I could use some coffee, Carla," he answered, then glanced at Hugh. "How about you? The coffee around here is great. So's the iced tea."

"Uh, coffee sounds good."

"Java on the way." She turned and left the room, hips swaying and anklets ringing.

"Eczema," Blackfeather said.

Hugh blinked. "Excuse me?"

"I saw you looking. Carla had eczema, along with a whole lot of other skin ailments. Shingles. Psoriasis. You wouldn't know it now, but when I first laid eyes on her she looked like she'd been deep-fried."

So the pitch was starting. Hugh put a properly amazed look on his face. "You cured her?"

"Yep, sure did." The big man settled back in his chair, regarding him with a disconcertingly sharp gaze. "You gay?"

Hugh frowned, taken off-guard by the question. He'd been expecting a follow-up shot of high pressure sales. "Uh, does it matter?"

Blackfeather grinned. "Not to me."

Hugh didn't dare seem too evasive. "Yeah," he admitted. "I'm gay."

A satisfied nod. "But that's not how you contracted Treatment Resistant AIDS."

"What makes you say that?"

"You don't seem like the kind of man who makes mistakes. You're tense, cautious, and wary. If your guard was up any higher you'd grow a shell." He shrugged. "Still, that's not too surprising, you being a lawman and all."

Hugh hid a wince behind a poker face. This guy had dug deeper than most. "People in my condition don't get to wear badges. I was a Minneapolis cop for fifteen years, but when I got sick I had to take medical retirement." Which was the truth, just not all of it.

"Ah, I see." Blackfeather glanced past him. "Here's the lovely Carla with our coffee." He stood up and relieved her of the tray she carried, then sent her away with some signal Hugh didn't quite catch.

"Tell me," he said as he sat down again and began pouring, "Doesn't the loss of your career make you feel lost and directionless?"

What the hell was this guy getting at? "My present direction," he answered stiffly, "Is trying to stay alive."

Blackfeather handed him a mug. "Excellent choice of priorities. Black, right?"

This whole thing was getting to be like some of the trickier stings he'd run back when he was working Vice and Bunco. The guy was shying from his ex-cop status, and working his way around to blowing him off. Some of these jokers had antennae like cockroaches. All it took was the faintest of vibes to send them scuttling for cover.

"Look, Doctor Blackfeather," he began, putting a desperate note in his voice. He'd wrestled eels like this guy to the mat before, and figured he had one more bout left in him. All he had to do was get the man's greed to kick in.

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"Oh, just call me George. All my patients do."

Hugh was left completely off-balance again. "You mean you *are* going to treat me?"

Blackfeather looked surprised. "Sure. After all, I contacted you, didn't I?"

"Yeah, you did." That was one of the nastier parts of these vultures' MOs, but it also made what he did easier. The world was glutted with information; all you needed to do was know how and where to look for what you wanted. That made it easy for these parasites to locate the few thousand TRAIDS sufferers, select the ones whose consumer profiles made the likeliest target for your style of scam, check the credit references of this group, and go after the fattest pigeons in the flock.

Blackfeather leaned closer, suddenly intent. "I'm pretty selective, Hugh. You fit the profile for the sort of subject I need at this point of the testing stage."

Planted financial records had seen to that. He figured his quarry was about to launch into his 'now don't expect immediate results' rap, handing out the mush-mouthed bet-hedging these pitiless bastards used to cover their asses. He knew how to play along to this particular tune.

"I'm willing to try anything. I've been to a dozen doctors, and none of the standard treatments work." He obligingly opened his mouth wider for the hook, adding, "Who knows, maybe I'll be one of the lucky ones, and your approach will work for me." He did his best to sound like he believed such a thing was possible. Maybe it was. The only problem was that the odds made climbing in an antique Corvair convertible and playing chicken with a two hundred-car freight train seem winnable by comparison.

Blackfeather shook his head. "Luck's got nothing to do with it. Figure in about three or four days you'll be well enough to leave here if you want, go on with your life."

These bastardsalways made grandiose claims, but this was the biggest, boldest-faced one he'd ever been handed. They always left themselves an out. Where was his?

"It must—it must be expensive," he said sounding cautious and worried. If he could get Chief Quack to name his price Hugh's case would be half made.

Blackfeather shrugged. "This isn't really about money, so there's not a set fee. In three days we sit down and have a talk. I tell you what I want. You don't like my price, you walk away."

Hugh nodded. "I guess that's fair enough." Now he had a handle on the dip-phase of the operation. He was working it like the faith healers. They'd trick you into thinking you felt better, get you falling all over yourself with gratitude, then pick you so clean so fast your accounts imploded. Tonto here was in for a heap big surprise. He wouldn't be getting Hugh's wallet, but a warrant. Cash value, zilch. Personal value, incalculable.

Blackfeather seemed pleased with his answer. "Great. So you're ready to start getting better?"

"Sure. What've I got to do, some herb and sweat-lodge sort of thing?"

Blackfeather threw back his head and laughed. "You are one funny guy, Hugh," he gasped as he tried to get control of his mirth. "I've seen a lot of folks sit there and think that, but none of them have ever had the balls to say it out loud."

He wiped his eyes. "No sweating or chanting, I promise." A wink. "Honest injun. First I give you a shot. Then we get you settled into a room here. You spend the next couple days taking it easy, mostly staying in bed. You get three meals a day, plus anything else you want to eat, whenever you want it. If you've trouble eating, which is pretty unlikely, there's some fairly tasty medical redbud in your bathroom medicine cabinet. Eating all you can and chilling out for a couple days are the only things I insist on. There's a brand-new forty-inch Gateway

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rig in your room. You've got full access and some three thousand channels. If you'd rather read real books, ring for Carla. I've got a pretty damn good library."

"Sounds like a vacation." Full access? He'd believe that when he saw it.

"Think of it as one." The big man shook his head. "I envy you, man. Opening game of the Series is tomorrow, and I'm going to be too damn busy to catch it." He stroked his chin thoughtfully. "What else? Oh yeah, you eat meat?"

"Yeah." Actually he didn't eat much of anything. Standing six-one and weighing maybe one-hundred pounds should make that obvious.

"Great. Chan—he's our chef—will be happy. He hates cooking for strict vegetarians." Blackfeather leaned back in his chair. "So what you say? Ready to get poked by the old horse-doctor?"

"That's all you need to know?" No physical, no medical records? Talk about playing it loose!

"Nope. I know everything I need to."

Hugh had thought he'd seen it all, but this guy's routine was something else. One magic shot, three-day cure, love offering payment plan. Either he was an amateur, or a the slickest pro Hugh had run across in a long time. Bagging him would be a special pleasure.

"I'm ready if you are."

Letting an animal doctor shoot him up with some unknown substance had been no big deal. From the very beginning Hugh's attitude had been that most of these quacks were unlikely to do him any real harm—you needed a living customer if you wanted a paying customer—and even if they did manage to kill him, his suffering would be over and they'd get the chair. Brass from the alphabet soup of agencies behind the Task Force kept saying this willingness to play guinea pig was heroic, but it was easy to be fatalistic when you had your headstone already picked out and paid for.

Blackfeather had injected him with some red stuff, probably colored saline and maybe some vitamins, then escorted him to a large cheery bedroom like you'd expect to get at a pricier B&B. Nice furniture, real art on the walls, flowers on the dresser, private bath, nothing bolted down.

He stood by while Hugh changed into a hospital johnny, suggested that he lay down and take a nap, then left him to his own devices.

Hugh waited a few minutes, then retrieved his pocket digipad from his bag. Using the tattle concealed inside it, he swept the room for bugs, found it clean. Then he checked the MV. Sure enough, he had the promised full access, but there wasn't a single sign of a lamprey or lurkline. Very odd.

Since he had clear air, he lit up a cigarette and sent a short coded message back to Arlington, letting the Task Force know he was in. By the time that was statted the exhaustion he'd been fighting all day was getting the upper hand.

Blackfeather wanted him to rest? No problem. He took a leak and flushed his butt, then stretched himself out on the brass bed thinking he'd just rest his eyes a few minutes.

The mattress was just right, embracing him like a lover. A day or two of this wouldn't be so bad. It might even help him rest up for enough for another hunt afterward.

"*Mr. Longworth? Hugh?*"

Hugh awoke with a start, found the blonde standing by his bed. How the hell had she snuck up on him?

"Yeah?" he croaked. *Carla.* That was her name. Looked more like a Buffy if you asked him.

"Time for supper."

He rubbed his eyes, yawned. "What time is it?"

"A bit after seven."

He groaned and pushed himself up so his back was against the pillows and headboard. He'd been down for the count almost five hours. Was it the shot, or just plain exhaustion?

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Carla rolled a hospital-type bedtable around so it was within easy reach. "You'll love Chan's cooking," she said as she began uncovering plates and bowls. "Tonight we've got our own squab, roasted with a honey-orange glaze and stuffed with wild rice dressing. Fresh asparagus, raw bean salad with basil vinaigrette. Fresh seven-grain rolls. Dessert's mince pie." She tapped a small covered container resting in a bowl of ice with a pink-painted fingernail. "Whipped cream for the pie in here."

Hugh stared at this repast, wondering how the hell they expected him to eat more than a couple mouthfuls. His appetite had gone belly-up months ago, hanging on maybe a year longer than his sex drive. This was more than he'd eaten in the past week.

Yet much to his surprise, the sight and smell of the food was setting off a veritable flood of saliva. His gut rumbled hopefully.

"Looks good, doesn't it?"

He looked up. "I guess."

She smiled and pinched her bare midriff. "Believe me, keeping my weight down even this low is the hardest job I face around here."

Hugh scooched around to get more comfortable, picked up his fork and gave the squab a tentative poke. He was pretty sure he'd never eaten one before. It looked like a runty chicken.

"So you work for Doctor Blackfeather?" he asked.

"I help him any way I can."

Interesting answer. He extracted a forkful of dressing. "You like a live-in nurse on the clinic payroll?" Unable to resist, he tasted it. A shiver of pleasure ran down his spine and his taste buds nearly popped their corks.

"I'm not a nurse, and it's not about pay." She jerked her chin toward his tray. "Look, you go ahead and eat. I'll provide some dinner theater."

"I don't—"

"Eat. Listen. They'll both do you a lot of good."

As if following her orders or its own agenda, his fork hand had twisted off a chunk of the orange-glazed breast. It brought the morsel toward his mouth. He had to open up or let his lips get speared. One taste and he knew it had been one of the best moves of his life.

"George told you that he treated me. Probably also told you I looked deep-fried first time he saw me. That's one of my lines. I'm a writer. Sold my first story when I was seventeen, my first novel at twenty. Around that same time minor skin problems began turning ugly. Eczema. Psoriasis. Shingles. Hives. You name it, I had it. By the time I hit thirty I looked like some sort of grade Z movie monster. I'd seen dozens of doctors. I was allergic to all the standard treatments and most of the alternative therapies. Infections had turned big patches of my hide into raw meat. By then I couldn't even write any more, the pain and itching were so bad I couldn't concentrate."

She shook her head and sighed. "When George contacted me I'd already saved up almost enough stuff for a nice OD. He convinced me he could help. So I drove myself down here from Seattle. That was hell, but I couldn't stand the thought of a whole plane load of people staring and probably losing their lunches over the way I looked."

Hugh paused between bites, knowing all too well how that felt. "He cured you?"

A solemn nod. "Damn straight. Now I can look in a mirror and not want to die. I'd catch a bullet for that man." Her eyes narrowed and her mouth hardened. "If I thought anyone was trying to hurt him, I'd kill them in a minute. No hesitation, no regrets."

Her fierce and absolutely unwavering sincerity made him shiver. She meant it, no doubt about that. He wondered if this warning was given to everybody, or directed at him alone because of his ex-cop status.

"I'm just here to get well," he said meekly.

"You will." She sighed and her shoul-

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ders slumped. "Look, I didn't mean to come on so heavy, but I've got reason to feel this way. George is . . . *special*. It's hard to explain. You read much?"

"Some," he admitted between bites.

"OK, think of it like the plot of a story. Suppose you were close to Pasteur. Or Salk or Sabin, somebody like that whose work could save uncountable lives. Wouldn't you think keeping him safe was worth your life?"

"I guess." Sounded kind of sci-fi to him.

"George is onto something bigger than a polio vaccine. Even bigger than a smallpox vaccine. What he's working on is something that will cure and create an immunity to hundreds, maybe even thousands of diseases."

Hugh swallowed a mouthful of bean salad. "That's a pretty big claim." Out of respect for the food he refrained from using the term bullshit.

Her face shone like that of a true believer. "I know. But I've seen it. He cured me. He's going to cure you. He's cured a lot of other people so far, and sometime in the near future he's going to cure more. Millions more. Billions more."

Why was it that every time he tried to talk he had his mouth full? "You said he's cured lots of people so far. How many?"

She considered, shrugged. "I don't know, maybe a hundred."

Hugh thought hard a moment, weighing the risk, deciding to go for it. "Do you think I could see some sort of list?"

Again that piercing gaze. This woman was one hell of a lot sharper than she looked at first glance. The moment stretched out, and he tried to look innocent.

Finally she shrugged. "I'll ask him." She reached for the tray. "Ready for me to take this away?"

Hugh looked down, blinked in surprise. The squab had been reduced to a pile of tiny bones. The stuffing was gone, along with the bean salad and both rolls. All that was left was the asparagus—which he hated—and the pie.

"Uh, sure." No wonder he felt so stuffed.

"I'll leave you the pie," she said with a wink, removing it and the whipped cream from the tray.

"God," he sighed, settling back against the pillows. "There's no way I can eat dessert after a dinner like that."

"Hey, you never know, you might surprise yourself." She picked up the tray and left the room, anklets jingling.

Five minutes later the pie was history.

Five minutes after that he was sound asleep again.

The next day passed in a blur; long periods of sleep broken only by Carla's arriving with yet more food. Groggy as he was, Hugh was also ravenous, scarfing down everything he was brought.

At breakfast he was forced to admit that he was too out of it to make it to the bathroom under his own steam. She didn't seem surprised, and helped him from the bed to the pot with the crisp efficiency of a trained nurse. The trip wrung him out, and he was asleep again almost as soon as his head hit the pillow.

As his TRAIDS had progressed Hugh had suffered countless periods of debilitating weakness, most of which he tended to deal with by driving himself to the point of this sort of collapse. He'd been on the verge of a meltdown for a while now. During those times when he was awake he wondered if this was just another episode, or if the shit Blackfeather had injected him with was causing it.

Wondering was as far as he got. Sleep stole away the ability to worry or make any sort of decision, to say nothing of take any sort of action. He would have asked Blackfeather, but the owner of the clinic never came around when Hugh was conscious. Once, maybe mid-afternoon, he came half-to and thought he heard the man saying, *Hang on, my friend, I want you feeling good and feisty.* Afterward he couldn't be sure if it had really happened, or had just been a fever dream.

Carla hung around when she brought

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his dinner, once again talking while he ate. She was writing a book on Blackfeather and the ground-breaking discovery he was working on. That she worshipped the man was obvious. She talked about other things as well, but Hugh was so wrapped up in stuffing his face that most of it went right over his head. Food seemed to be the only thing he could focus on, and it felt so good to eat again he didn't really care.

After he'd cleaned his plate she helped him to the bathroom and back. After promising that she or someone else would be back to help him make a before-bed pitstop, she left him alone again.

Exerting all the force of will he could muster, he tried to stay awake to watch the Series opener.

The last thing he remembered was the second batter of the first inning, and even that was pretty hazy.

"Time to tap a kidney, Hugh."

Hugh woke, found Blackfeather at his bedside. The man looked tired but pleased. "What time is it?" he asked, stifling a jaw-cracking yawn.

"A little after eleven." He gestured toward the screen. "How was the game?"

"I fell asleep. Again."

"Well, I did manage to catch the last inning. You didn't miss much."

"If you say so." Hugh picked up the remote and turned the set off. "Listen, should I be sleeping this much?"

Blackfeather nodded. "Actually, yes. Don't get worried about being so out to lunch. You'll feel perkier tomorrow, I promise."

"Jesus, I hope so. It's like I caught frigging narcolepsy."

"You haven't. Now you'll still be wiped out tomorrow, but you will be able to keep your eyes open for more than five minutes at a knock. So, you ready to go bleed the weasel before bed?"

"Yeah," Hugh managed to sit up and swing his legs over the edge of the bed, then had to pause to rest. "Jesus," he muttered. "I feel like I should be singing Melancholy Baby."

Blackfeather chuckled and helped him stand. His big brown hands were gentle and warm. "Tell you what, kitten. I'll give you a reason to stay awake tomorrow."

"Like what?"

"If you feel up to it, access the file 'Patient List'. I already set it up in a file space under your name."

Hugh had to let this unexpected offer stay on the back burner, it took all of his concentration to keep his legs under him as he tottered to the bathroom. Without the vet's help he probably wouldn't have made it.

"I got to do this sitting down," he mumbled when they got inside. "I try to piss standing up and I'll go in head first."

"It's your potty." Blackfeather steadied him as he got settled on the seat. "You want me to wait outside?"

Hugh shook his head. "A couple years of regular AIDS treatments make you used to working before an audience." He peered up at the man curiously. "You're really going to let me look at a list of your patients?"

Blackfeather leaned against the doorframe, crossed his arms. "Sure. I've got nothing to hide from you."

Hugh doubted that. "What about patient confidentiality?"

He snickered. "I'm a veterinarian, remember? Besides, we're all in this thing together."

"What does that mean?"

"Just that. You done?"

"I guess." It seemed that subject was closed. He took the hand he was offered, managed to get to his feet. He gritted his teeth until the room quit yawing, let the other man steady him while he washed his hands. Then they began the long trek back to his bed. Ten feet, tops. It felt like ten miles.

"Look," Blackfeather said as he helped Hugh get back under the covers. "I know my approach seems kind of strange. I guess maybe it is. All I can say

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right now is that I'm going about all this in the way that seems best for the circumstances. Most folks tend to agree once they understand the whys and wherefores. I think you will, too. I know it's hard for a man in your position, but for now you just have to trust me." He met Hugh's gaze squarely. "Think you can do that?"

"I guess." In a peculiar way his gentle, down-to-earth manner did inspire trust. But there was no way for Hugh to forget that he was here on a vulture-hunt. Maybe this man's veterinary practice paid for this big house, fancy grounds, private chef and all, but he doubted it. When money moved in situations like this you could pretty much bet on finding a trail of slime behind it. The man was up to something hinky or he wouldn't be contacting patients on the sly.

Blackfeather smiled. "Only a little, huh? Well, I guess that's to be expected. We can't expect miracles."

"You promised me one," Hugh pointed out stiffly.

Instead of getting angry or defensive, Blackfeather only laughed. "I did, didn't I?" He leaned down, arranged Hugh's covers, patted his shoulder. "Then I guess I better not disappoint you."

When Carla woke Hugh up the next morning he found that the mental fog had cleared considerably. While still bone-tired and a bit fuzzy around the edges, he wasn't in any worse shape than the day he'd arrived at the clinic. About average for a man dying of TRAIDS.

Carla tagged along to spot him, but he made it to the bathroom and back on his own. Once back in bed he ate a breakfast big enough to give a lumberjack indigestion.

After she left he snuck a cigarette, then used the tattle to recheck the lines. Once again the system got a clean bill of health. After an OK message to Arlington he went hunting for the file Blackfeather had promised. The man was as good as his word. It was right where he said it would be.

Being given this and free access didn't make sense. It was almost as if Blackfeather not only knew for sure he was still law, but also *wanted* him to investigate.

Hugh planned to oblige. Odds were that the file and the names it contained were bogus. If that were the case, he'd find out soon enough. He had clearance to dig one hell of a lot deeper than your average Bunco cop. There were one hundred and eleven names on the list. He took a methodical approach, beginning with *Abrazzo, Antoinette Maria.*

By the time Carla returned with his lunch he was just about done with *Barkley, Deneesha Martina.* Although Blackfeather himself had handed him the list and the access, he still bosskeyed over to a sports channel when he heard her at the door. Those ankle bells made it easy to her hear coming.

After she was gone again he went back to work, moving faster now that he had a search protocol dialed in, and stopping only once before supper time. That was to call and ask for a snack, and this after a monster toasted BLT on thick slices of homemade bread, a mound of fries, two big pickles and chocolate mousse for lunch!

Whatever else Blackfeather had or hadn't done, he sure had raised Hugh's appetite from the dead.

"So, you got it all figured out?" Carla asked as she uncovered his supper. When he saw the thick juicy steak on his plate it was all he could do to keep from grabbing it with his hands and wolfing it down like a starved pit bull.

"What do you mean?" he asked in a wary tone.

She shook her head. "Come on, I know George gave you a list of former patients. Remember, I'm the one who asked him for you."

"I was watching sports all day," he answered defensively.

"Sure, I guess that's one name for

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what was on when I brought you lunch," she agreed, an impish smile twisting her lips. "But somehow I can't see a guy like you getting all that worked up over women's nude volleyball."

He'd hoped she hadn't noticed. Not much point in lying. They weren't coming right out and saying so, but they seemed aware he was still a cop and on the job. There was some sort of cat and mouse game going on, and the big question was who was which.

"Yeah," he admitted, "I checked a few."

"And?"

"It didn't make any sense. It's like he was picking patients at random. If there's a pattern, I can't see it."

"That's because you're looking for the wrong thing." She nudged his tray closer. "Go ahead and eat, I'll talk. Might as well keep our dinner ritual going."

"OK." No argument there, the smell of the food was driving him crazy. He grabbed his knife and fork, went to work on the steak.

"Let's see. You found me in there, a writer with bad skin disease. A magazine editor with malaria. A software designer with ovarian cancer. How about the Federal Judge with TRAIDS?"

Hugh shook his head, his mouth too full of meat and shitake mushrooms to speak.

"That's right, with a name like Waszczlabski she'd be near the end of the list. Maybe a quarter of people suffered from TRAIDS, right? The rest were all over the map. Leukemia. Rocky Mountain Spotted Fever. Rotobacter. TB. Encephalitis. Meningitis. Liver cancer. Lyme Disease. A type staph. Did you figure out the one thing we all had in common?"

He paused with a roll halfway to his mouth. "You were all really sick and considered incurable?"

"Right. Too sick to work, and either waiting to die or working ourselves up to doing a Dr. Jack." She got quiet for a minute, clearly remembering what it had been like to contemplate suicide. Hugh waited, stuffing his face and remembering his own dark moments when having his gun for takeout had begun sounding like a really terrific idea.

"Then George came into our lives," she said, her face brightening. "Now we're back among the living. We're useful again, and we wait."

Hugh swallowed his mouthful of baked potato. "Wait for what?"

"The right time."

"The right time for what?"

She grinned and shook her head, blond curls dancing. "It isn't the right time to tell you yet."

By the time he decided to call it a night he still hadn't nailed it down. Some of Blackfeather's former patients had given him money, some hadn't. The man had said it wasn't about money, and that seemed to be the case. All he knew for sure was that each one had indeed been terminal before coming here, all but one who had died in a plane crash were still alive and seemingly completely recovered.

Odder yet, a vague comment about attributing their renewed health to luck made by one of them had sent him backtracking through the others. This led him to find one other unifying factor, and a damned strange one at that. Not a single one of them had ever mentioned George Blackfeather as the source of their cure. It was like each and every one of them had been sworn to secrecy.

On the face of it Blackfeather's treatment was looking more and more like the real thing all the time—a conclusion Hugh had a hard time swallowing. One shot, three days to a cure for everything from TRAIDS through cancer? Maybe in Oz, but not in the real world. And if you did have a magic bullet, why the sneaking around and secrecy when you had a shot at gigabuck funding and probably the Nobel Prize?

It just didn't add up. He was tempted to stat the list of names to Arlington to see what they could do with it, but held off.

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Almost every vulture-hunt so far had been an open-and-shut-case, the malfeasance and fraud so glaringly obvious that his investigation hardly deserved that name. This one was different, a riddle wrapped in a puzzle buried in a head-scratcher. He wanted to break it himself, doing one last bit of real police work before he went for his ride in a flag-draped coffin.

Tomorrow was the day he and Blackfeather were supposed to have their talk about what this was costing. He was willing to bet all the pieces would come together then.

Carla stuck her head in around eleven, asking if he needed any help getting to the john. He told her no. While this exchange was going on she seemed to be watching his face closely. Having people stare was nothing new, but he did have to wonder why this sudden interest.

So when he went into the bathroom, instead of just draining his bladder by nightlight, he flipped on the lights so he could look at himself in the mirror. This was something he didn't do very often any more. He'd never been much of a pretty boy to start with, and TRAIDS hadn't done much to improve his mug.

Blinking against the glare, he focused on his image in the mirror.

His breath locked up in his throat. He squeezed his eyes shut a moment, leaned closer and examined first one side of his face and then the other.

"No," he whispered into the echoing silence, arguing with the evidence. Every one of his lesions had shrunk by five, maybe even ten percent, their retreating edges surrounded pink new skin. Not only that, the sallow, cadaverous pallor he'd had for so long had improved. Just a little, but more than enough to be noticeable.

He straightened up, unable to look away from his reflection, and his heart banging against his ribs. He cautiously touched the healed flesh haloing a lesion on his jawline, half expecting it to be makeup or something like that, and have it come off on his fingertip.

It stayed—it even tingled. His eyes hadn't deceived him.

His hand fell. Could it be that this guy was for *real*?

Cop cynicism tempered by a year and a half of vulture hunting and armored by terminal fatalism said *No way.* It had to be a trick. This was how these bastards worked, pulling some slick bit of sleight of hand that got you hoping, and once you swallowed the hook they reeled you in and gutted you.

Then how to explain *this*? Kaposi's sarcoma wasn't something you could send into remission with the power of suggestion or cosmetic snake-oil.

He shook his head and leaned against the counter. There had to be a logical answer. Maybe Blackfeather did have something that helped the skin. Look better, feel better, right? Say Carla's story was true, and her hero was using one kind of cure to convince people he had another kind. Bait and switch. Oldest trick in the book.

He took a thoughtful leak, turned out the light and headed back to bed. Lit a cigarette and sat there telling himself that he was being scammed. He was no scientist, but he'd been through enough AIDS treatments to reach TRAIDS status, and waded hip-deep in the grifts which had sprung up to fleece TRAIDS sufferers long enough to know that there was no such thing as a one-shot three day cure. It was flat out im-fucking-possible.

He snuffed out his smoke and crawled under the covers. Turned off the light. Lay there waiting for the sleep which had come so easily the day before.

As he stared into the darkness, a part of himself which had shut down the day the doctors had delivered his death sentence shifted uneasily, stirring in a case-hardened chamber of his heart.

When he finally fell asleep he was still struggling with that traitor hope, trying to keep it buried where it belonged.

George Blackfeather arrived just as Hugh was finishing up yet another enor-

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mous breakfast. A four-inch stack of buckwheat pancakes served with a fresh fruit compote and maple syrup, what looked like half a pound of bacon, grits, fresh-squeezed orange juice. If he kept eating like this he was going to make history as the first TRAIDS victim who went up like the Hindenburg from overeating.

"How you feeling this morning?" Blackfeather asked as he sauntered in. He was dressed in jeans and sneakers again, and wore a t-shirt advertising a band called The Martian Dating Service.

"OK, I guess," Hugh answered in a guarded tone. The truth of the matter was that he felt better than he had in months. His head was clear and his body didn't feel like a used dishrag.

"Glad to hear it. You up for a walk outside?"

"Do I get to wear real clothes?" The walk sounded wonderful, but no way he was going out with his ass hanging out the back of this damn johnny.

"Sure do. Pants and everything."

Hugh inhaled the last slice of bacon, wiped his mouth. "Sign me up."

Blackfeather took him out the back door and onto the rear of the property. Once again the air was filled with the scent of flowers, their sweet perfume stained by a whiff of rot and decay. Competing with this mix was the barnyard smell of manure coming from the barns and pens. Hugh didn't mind. The sun felt good on his face and shoulders, and his legs were steadier than they'd been in weeks. It didn't even hurt to bend and pet a black cat which threaded its way between his feet, and proper homage offered, went flying off again.

The veterinarian guided him toward a tall white building attached to a big covered enclosure filled with posts and dead trees.

"Where we going?"

"To let my friends out for the day."

Hugh assumed the man was talking about animals. "How many critters you got here, anyway?"

"Oh, maybe forty if you don't count the birds."

"You mean like that squab I ate the other night? What *is* squab, anyway? Some kind of pygmy chicken?"

Blackfeather smiled. "Actually it's pigeon."

Hugh missed a step, his stomach doing a backflip. "I ate *pigeon*?"

"Tasty little sucker, wasn't it?" The big man pulled out a keyring and unlocked the door to the building. "Now I warn you, it's kind of rank in here."

"Sure." Hugh answered, not really paying attention. He'd eaten *pigeon*? The damn things were nothing but rats with wings! He trailed Blackfeather into the darkness, stopped dead in his tracks. "Christ! What's that smell?"

"My friends." Blackfeather flipped a switch by the door. There was the dull clunk of a relay closing, then banks of lights high in the rafters blazed on.

"So, Marshal Longworth," he continued quietly, "What do you think?"

Hugh stood there, hands in his pockets, feet rooted to the floor, brain racing a million miles an hour, tongue frozen solid.

There around him was bare concrete littered with bones. Set in the cement were an assortment of short poles and dead trees. Roosting on these perches were twenty, thirty, Jesus, over *forty* of the biggest and ugliest birds in creation. He was surrounded by buzzards, and they were all staring down at him with cool reptile estimation.

One part of his mind was trying to figure out why he'd been led into a room full of vultures, and not much liking the answer he was getting. The other part was working on his just being called Marshal, wondering why that chunk of top secret info was being brought up now, and making some fairly unpleasant connections with what the other lobe was processing.

"Why—why did you call me that?" he stammered at last, trying to divide his attention between Blackfeather and the

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avian thugs surrounding him. Did he dare take his hands out of his pockets and go for the panic button hidden in his watch?

The man who had led him into this terrible place grinned back at him, giving no immediate answer. Hugh searched his face and eyes for that telltale psycho gleam. It didn't seem possible that he read the man this badly. If he had, he was screwed. His gun was back in his bag. Three or four years ago he might have been able to take on a man the vet's size hand to hand, but if it came to that now he was dead meat. He would truly be buzzard bait.

"Because that's what your badge says, doesn't it?" Blackfeather said at last, his eyes sparkling with glee. "But I'll make you a deal. I'll just keep calling you Hugh if you promise not to call me Doc."

"Sure, no problem," Hugh answered cautiously.

"Great." Blackfeather turned aside, flipped up a steel box covering a big red button. When he pressed it an oversized overhead door began to roll upward. A vulture perched atop it let out an aggrieved squawk, unfurled tremendous wings and leapt into the air. Hugh cringed back, but the massive creature only sailed to a vacant perch, primly rearranged its feathers, then sat there glaring at him as if it was his fault that it had been disturbed.

"Now our blood brothers can go out and play," Blackfeather said, turning back and inspecting his face. "You, my friend, look a little green around the gills. Want to go back outside where the air is fresher?"

"Uh, sure," Hugh croaked, relieved he wasn't about to become vulture entree and eager to get away from the smell. He didn't sprint past Blackfeather when he opened the door, but he didn't hang around for more birdwatching either.

Blackfeather led him to a corner of the property where several pieces of weathered, well-used outdoor furniture were set on a deck built under the spreading branches of a huge shade tree. Carla and a short, gray-haired Oriental man were there, setting out what looked like a picnic from a big wicker hamper.

Carla glanced up as they approached, smiled. "Whoa, looks like George's babies grossed you out."

"I guess they did," he admitted.

The other man, who he figured had to be Chan, beckoned him toward a chair. "Well sit yourself down, suh," he said in a molasses-thick Southern drawl. "Have yourself some coffee. We got us some fresh muffins here, but I'm betting some of my beignets will fix you up right as rain."

Blackfeather motioned Hugh toward the chair Chan had indicated. "Sit down, take a load off." He dropped into the chair beside it. "We desperately need two black coffees, Carla."

"Here."

"Thanks," Hugh said as she handed him a steaming mug. Chan placed a basket filled with muffins and what looked like some sort of sugared donuts within easy reach. The two of them sat down, sipped their own coffees and waited for Blackfeather to speak.

"OK," he said after taking a slug of his own coffee and inhaling two of the beignets, "Where you want to start?"

Hugh took a deep breath. He didn't want to ask, but he had to. *Had* to. "Am I really cured?" He swallowed hard. "I—I haven't felt this good in months. I mean I'm tired, and I know I'm still sick, but something's changed. I don't feel as . . ."

"As close to death?" Blackfeather suggested gently. "Well, you're on the mend. It'll take time for your viral level to drop to zero and for your skin to clear up completely, but as of now your immune system is no longer compromised. In fact, it's on the attack, and it's kicking ass."

"How?"

"With a little help from my friends."

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Hugh stared at him in disbelief. "Those *buzzards*?"

"Be nice, call them vultures. They're why you're feeling better. You see, what I did was fix you up with part of their immune system."

"You're kidding, right?"

"Nope." Blackfeather met his gaze squarely. "I really did, Hugh."

He obviously wasn't joking. "Why?"

"Because vultures have some of the best damn immune systems on the planet." He chuckled and helped himself to another beignet. "The way they eat they *have* to."

Hugh remembered the red stuff in the shot. "So you're telling me you injected me with buz—vulture blood?"

"With refined and cultured components originally taken from their blood. A special cocktail of granulocytes, monocytes, lymphocytes and soluble proteins. I call it Blackfeather's Brew. Catchy, huh?"

"I guess." Hugh knew that several different plant and animal biologics had been used in medicine, and some were capable of fighting cancer, AIDS, and other diseases. None of them had anywhere near the kick this stuff seemed to have. But *vultures*! He shuddered, wondering if he was going to develop a sudden craving for roadkill. The way he'd been eating lately, he'd be cruising the highways constantly, maybe even running over stuff on purpose.

"Don't let it freak you out," Blackfeather said gently. "You won't turn into some sort of ghoul." His smile turned rueful. "Vultures have gotten a bad rap. Not many people find them as beautiful as I do. Still, once they save your life they begin to look a lot prettier."

Hugh frowned, unsure if he was reading this comment correctly. "You? You've taken your, uh, brew?"

"I was the first. See, I've always been fond of them, the vulture being my totem animal and all. Kept a few as pets, at first mostly American turkey vultures I rehabilitated. Then I bought a couple African vultures off a zoo. One night a few years back I had the news on, and it showed the results of another Ebola outbreak in Africa. One shot was of a vulture picking at a corpse. I went *yuk* like everybody else probably did, but then I got to thinking. Why, after hundreds of years of deadly disease outbreaks, were there still vultures around to eat the dead? Only one answer made sense. They didn't get the disease."

"Which meant they were immune."

"That was a real forehead-slapper, let me tell you! So I got me even more vultures and began experimenting. To tell you the truth, I wasn't thinking about people. I was working on a sort of immune-system booster for animals. After a helluva lot of false starts and just plain failures, I finally was homing in on it. I had just started to test it on something other than mice when I had my hand forced and went straight to human trial."

"What happened?"

Blackfeather shrugged. "I was bitten by a rabid coyote."

Hugh listened to the rest of the story in a daze. Most vets get prophylactic shots to protect them against exposure to rabies. Blackfeather never had because he was allergic to the serum. The same held true for the after-exposure treatment. He knew he was screwed if he didn't do something, and decided to try his brew on himself. The serum had worked just fine, although he had nearly overdosed on it, and being alone during that inital feverish period of sleep and ravenous hunger had nearly done him in.

He went back to animal trials, but a few months later he'd used it on another human, this time on an old college friend with inoperable brain cancer. This time he was there to help her through, and a damn good thing too, for it turned out that in maybe one out of ten cases there was a fever spike in the first few hours, one that could run dangerously high. During Hugh's first conk-

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out he had been watched carefully, and everything necessary for an alcohol and ice bath had been standing by.

Soon after that second patient he'd read in the paper about a successful restaurateur in New Orleans whose daughter had contracted a virulent form of liver parasite while in the Peace Corps. That was Chan, who afterward became not only his chef, but his business advisor. After that had been an RN from Detroit with antibiotic-resistant Staph A. Then he treated the son of the woman who did most of his computer work for him, saving him from a deadly bout of *E. coli*. After that he'd reached out to a heavily decorated female firefighter dying of TRAIDS. Each time Blackfeather's Brew had saved the person it was given to from certain death. Each time the interval before he tried it on another person grew shorter.

Hugh reached the point where he could remain silent no longer. He interrupted to ask the question which had been growing larger and larger in his mind all through this litany.

"Why me?"

"'Cause I liked your work," Blackfeather answered in a serious tone. "I admired your dedication."

Hugh shook his head. "I don't get it." Might as well lay all his cards on the table. "I came here to *bust* you, George."

"I know. See, one of my early test patients was the son of this lady named Deneesha Barkley. Dee can make a computer get up on its hind legs and do the tango, and waltz past any security you put in front of her. She got wind of the Federal Task Force hunting down TRAIDS quacks, and she's been keeping tabs on the work you and the other Marshals have been doing since. You, my man, hunted like an eagle, but your hunting days were nearly over. I wanted you on our team, so I lured you here and cured your TRAIDS." A crooked grin slipped onto his face. "Hope you don't mind."

"I'll let it pass," Hugh said tonelessly. "So what happens now? What is it you want from me?"

"Well, first off, I was kind of hoping for a passing grade under Studds-Whitechapel."

That was an act passed in 2002, cosponsored by two of the strangest political bedfellows ever. Gerry Studds was an openly gay Congressman, and a tireless advocate of rights for AIDS patients. Senator Vincent Whitechapel was an ultra-right-wing homophobe whose son died while waiting for official permission to receive an experimental treatment for leukemia. The act they created stated that a person with an untreatable terminal illness had the right to seek out and participate in any unapproved treatment he or she saw fit, and the providers of such treatment were within their legal rights to provide such for so long as said treatments were offered with full disclosure and in good faith.

While this had cut certain killing red tape and opened the door for a multitude of alternative therapies which did in some cases prove to be effective, any number of quacks and charlatans had seized on it as a license to turn a quick buck. Policing this criminal subculture was a job which had been undertaken by Hugh and about three dozen other former police officers suffering from untreatable terminal illnesses. The only cop job where the fact that you were dying—and looked it—could prove an asset. If there was one law Hugh knew by heart, this was it.

"No," he said slowly, "You're OK there. Your disclosure kind of sucks, but the key phrase is *in good faith*." He looked Blackfeather in the eye. "I have to write this up, but the case will be closed and marked as 'dismissed, no evidence of malfeasance or fraud'."

His eyes widened in sudden realization. "Jesus, this will be my last undercover operation, won't it? I'll be too healthy to pass as buzzard bait."

"You sure will," Blackfeather agreed.

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"Sorry to put you out of work, but I'd like to make it up to you. See, I have a job offer if you're interested."

"Doing what?"

"We need a Director of Security." The big man jerked his thumb toward Carla. "I can't have her going around and threatening my patients, can I?"

She made a face and stuck out her tongue. Chan snickered and said, "I tole you he knew, sugah."

Blackfeather turned back toward Hugh, his smile fading. "I'm going public with this pretty soon now. Janey—she's a biochemist who works with us—and I have pretty well gotten mass production of the serum worked out. That was one of my big concerns. I didn't want this to lead to vultures being hunted down and bled, and maybe even becoming an endangered species."

His expression turned grim. "When we do go public there are going to be a lot of bases to cover. This place is going to become a zoo, swarming with reporters and people wanting to get better. I know how a vet saying he's got a vulture-based cure is going to sound. Every law agency and government department you can think of is going to come down on me like a ton of bricks. I figure a former Special Marshal who got cured here would be a big help in keeping me out of jail. Then there's the big pharmaceutical companies. Half are going to be trying to rip us off, the other half trying to bury us because my brew will make most of what they sell obsolete. There's over a hundred former patients waiting to pitch in when the shit hits the fan, but we're going to need all the help we can get. I'd sure like yours."

Hugh sat there, his head spinning. He was *cured*. He was out of a job. Blackfeather wanted him to join his peculiar enterprise and help take on the government, the media, and Big Medicine.

It was all too much to absorb at once, he was still having a hard time coming to terms with the fact he wasn't in hot pursuit of death. He had to get away, had to get it all straight in his head.

"I—" he began, spreading his hands helplessly.

"You need some time to think it over," Blackfeather said in a kindly tone. "That's cool. I want you on our side, but I don't want you to feel pressured. Like I said the day you got here: you don't like my price, you can walk away. No hard feelings as long as you keep what we're doing under your hat."

"Thanks." Hugh stood up and began slowly walking back toward the house.

"Hope you all at least stay for dinner!" Chan called after him. "We're having blackened salmon!"

By the time he reached his bedroom he knew what he had to do. He found the sport coat he'd been wearing when he arrived, dug through the pockets and found the card given him by the cabbie who had given him a ride. His hands shook as he punched in the number.

He was waiting outside the gate and smoking a cigarette when the cab rolled to a halt. The Latino woman was still wearing the same tweed mac as the day before, but her hair had been dyed purple since he'd seen her last.

"Ready for a ride back to the airport?" She glanced around. "Where's your bag?"

"It doesn't matter." First he handed her his cigarettes. "Keep these for me." Then he pulled out his flashwad, peeled six five-hundred-dollar bills off the top and handed them over as well. "Please put this in that fund you told me about. And thanks for your help. I'm sorry I was such a jerk."

She accepted the money, squinted up at him. "So you're staying here for a while?"

"Yeah, I guess I am."

She beamed at him. "Good for you. Any idea how long?"

Hugh smiled back as he crushed his last cigarette out underfoot.

"For life."■

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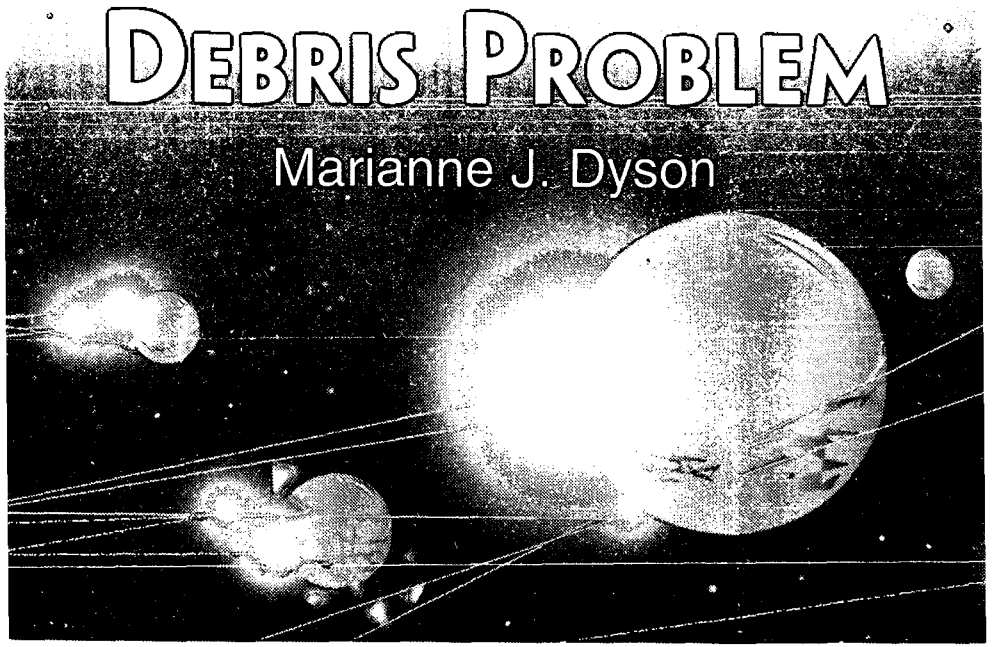
A Solution to the Orbital Debris Problem

Marianne J. Dyson



A smart young zonel on the planet Grep waved his eyestalks in excitement as he reported finding evidence of intelligent life around a small yellow star in their galactic neighborhood. He explained to the Supreme Zutteral that if they would fund the Contact program to blanket the yellow system with replicating probes, it might only take two revolutions to start reaping the benefits. The Supreme Zutteral approved a third of his request. With so little funding, they would be lucky if enough probes survived atmospheric entry to make contact with the intelligent beings. There was nothing the zonel could do about it, though. He built as many little probes as funding permitted and sent them on their way.

A smart young human on the planet Earth waved his hands in excitement as he described a technical solution for the ever-growing orbital debris problem. He explained to the Senate Committee that if they would fund the Orion laser debris sweeper, it might only take two years to clear space of this dangerous and expensive problem. The Senate approved a third of his request. With so little funding, they would be lucky to pay the electric bill for the lab. But there was nothing the human could do about it. He built the best little laser

Illustration by Shirley Chan

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system he could and began demonstrating its operation.

The frustrated zonel's eystalks drooped as he explained the lack of contact with the beings of the yellow star. He urgently requested they fund more replicating probes. With lots of them, surely one would make contact. The Supreme Zutteral argued the merits of contact, but finally agreed more probes were needed. The frustrated zonel was instructed to cut his staff and use the extra funds to send more probes.

The frustrated human's hands drooped at his sides as he explained the apparent increase in orbital debris since the laser sweeper began operating. He urgently requested funds for a more powerful laser. With more power, surely the laser would sweep the debris from orbit. The Senate Committee argued the merits of powerful lasers, but finally agreed they were needed. The frustrated human was instructed to cut his staff and use the extra funds to build his laser.

The worried zonel's eyestalks shook as he reported the ruthless attack and destruction of the contact probes. It seemed the increased number of probes had been interpreted as a declaration of war. The Supreme Zutteral wanted to study the problem more, but the zonel explained the dangerous urgency of the situation. They fully funded tens of thousands of seek-and-destroy probes equipped with decoys to quickly overwhelm their new enemy.

The worried human's hands shook as he reported the increase in laser power had somehow generated more and more debris. It seemed the laser was too powerful and was causing objects to explode into high-speed fragments. The Senate Committee wanted to study the problem more, but the human explained the dangerous urgency of the situation. They fully funded an even more powerful laser to destroy the high-speed fragments and save their satellite systems.

The tired zonel's eyestalks twisted as he reported the systematic destruction of the seek-and-destroy probes, including the decoys. He assured the Supreme Zutteral that with enough funding, he could beat their new enemy with a new line of larger probes.

But, to prevent this aggressive race from tracing a probe back to Greb (already the Coalition of Supremes had passed a resolution banning contact), the Supreme Zutteral ordered the deployment of nano-droids to remove all evidence of the probes. Furthermore, they would send out no more probes for fear of starting a war they couldn't win. (Besides, probes were too expensive.) The zonel insisted the larger probes could solve problems like orbital debris for peaceful races they might contact. He was honked out of the assembly.

The tired human's hands sweated as he reported that Earth orbit was now debris-free, but also satellite-free. He assured the Senate Committee that with enough funding, he could create a line of selective-targeting sweep lasers.

But, to prevent the sweep laser being used as a weapon (already the United Nations had passed a resolution banning sweep laser weapons), the Senate Committee ordered it be disassembled. Furthermore, there would be no more sweep lasers built for fear of starting an arms race they couldn't win. (Besides, lasers were too expensive.) The human insisted that selective-targeting sweep lasers would be needed to someday defend the planet from alien attack. He was laughed out of the room.

The contact problem solved (there would be no more contacts), the zonel eventually found employment designing orbital lasers.

The orbital debris problem solved (there were no satellites to get hit), the human eventually found employment designing probes to search for intelligent life.■

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John G. Hemry

ODYSSEUS

Tradition is a powerful force in human affairs—even if it must adapt to radically new conditions.

Illustration by Vincent DiFate

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It was an accident, really, an accident so improbable as to be within a hair's breadth of impossible. Yet, every individual human life is the sum of similar vast improbabilities, so the accident may have had a certain cosmic inevitability about it. I don't know. I drive ships for a living, and leave Big Questions to the priests, philosophers, and physicists.

My Chief Engineer, Val Steiner, triggered this particular accident. "The primary Umbari Coil's drifted slightly out of alignment. We need to drop out of U-Space long enough to recalibrate."

I shrugged in reply. As decisions by a ship's captain go, this was an easy one. "If we gotta, we gotta. How long will it take?"

"Half a day. Maybe."

"Maybe?" I signaled annoyance with an aggravated frown.

Steiner just smiled, secure on her pillar as god of the machinery that made my ship work. "If there's no complications."

"And if there are?"

"It'll take longer."

One of my passengers happened to be present, and now he leaned forward, frowning as well, though in a questioning way. "Excuse me, Captain. Why is this a problem? Doesn't your ship have a back-up coil?"

I smiled reassuringly back at him. "Sure, Mister Garand. That's the rule. Every ship is required to have two fully functioning Umbari Coils running. That's why we have to recalibrate the primary one. If it drifts far enough out of alignment to fail, or if we can't calibrate it, we just pop in a replacement coil immediately. No big deal."

"But we have to drop out of U-space?" Garand didn't seem particularly reassured. "We're not in distress, are we?"

Val shot him her own confident grin. "Of course not. And once we've recalibrated the primary coil, we'll be sure we won't be in distress anytime soon. Just a little preventive maintenance, that's all."

Garand nodded and left the bridge, still looking somewhat uncertain.

"Thanks for not mentioning the failure rate of Umbari Coils. That might have scared the passengers," I mockingly praised Val.

She sketched a sarcastic salute with her right hand in reply. "No problem, Captain. Besides, my coils don't fail."

"Sure. That's why we've got two working constantly." I triggered the all-hands circuit to warn we were dropping out of U-space, waited several minutes to give everyone a chance to strap down, then initiated the sequence. The world swam off-balance/inside-out for a moment, then the screens cleared to reveal the black emptiness of interstellar space. A trillion stars stared down coldly, their light magnificent but frightening, like distant fires mocking someone drowning in a sea vacant of everything but the certainty of lonely death.

Or it should have been vacant. Instead, Victoria Watabayashi, my First Officer, turned to me with an expression of amazement. "I'm picking up a ship's beacon."

"You're kidding."

"Nope." Wata adjusted her controls, fingers dancing across the panel as if she were a pianist. "The signal's really strong, boss. We're almost on top of it."

"Jesus. Another ship in normal space between stars and we dropped out into its lap. What are the odds of that?"

"Beats me." Wata's fingers played another brief tune. "Strange. I can't ID the beacon. It's not in the current ships' registry."

"So check every reference we've got. If it's in space, one of those should have it."

"Doing it now." She smiled. "Got it. Registry is . . ." Wata's face paled as her smile vanished.

"What's the matter?" I keyed my own panel to view the readout, then froze in turn. "*Odysseus?*" I finally whispered.

"*Odysseus*," Wata confirmed in a shaky voice.

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My ship's mess deck didn't fit anyone's definition of spacious, but it did encompass barely enough room for my few crew members and even fewer passengers to all gather together. The crew, experienced enough to know such a meeting while underway was extremely unusual, stared at me with a mixture of misgiving and curiosity, while the passengers idly waited in blissful ignorance. "Okay, everybody, we've encountered another ship." My crew's wonderment visibly intensified, in counterpart to the calm acceptance of the news by the passengers. "Not just any ship. It's the *Odysseus*."

It took a moment for every member of the crew to realize the significance. The reaction was palpable enough for even the passengers to notice this time. One of those passengers, a physician named Ortega, pointed a blunt finger my way. "What does that mean? What is special about this other ship named *Odysseus*?"

Val answered before I could. "*Odysseus* was the first," she advised. "The first manned ship outfitted with a prototype Umbari Coil, the first ship sent off to another star. The same star, as a matter of fact, that we're heading for."

"I see. Did it reach the star?"

"No one knew, until now. *Odysseus* jumped into U-space, and vanished. Nobody has ever known what happened to her, but there's been speculation that she was doomed when her Umbari Coil failed. She only had one."

"Only one?" Garand wondered. "You confirmed to me earlier that every ship now has to have two. Why did they only have one?"

"They thought one was enough," Val stated curtly. "They were wrong."

"The fact that we've found *Odysseus*," I added, "tends to confirm that theory. We're closing on the derelict, and so far we haven't seen any obvious external damage. It's still on course for its destination, though it won't get there for more than another century yet at the speed it's making in normal space."

"Derelict?" Doctor Ortega questioned. "This means the crew is dead?"

"It's been almost two hundred years," Val pointed out. "There's not a ship made which can sustain a closed environment that long, even when everything is working, and Umbari Coils tend to drag other equipment down when they fail. Most likely, the crew's been dead for almost the entire time."

Silence reigned for a moment, then somebody whispered the word I knew would come up sooner or later: "Salvage."

"Yeah," I immediately agreed, before a dozen disparate conversations could spring up on their own. "The *Odysseus* is derelict, long-abandoned. Whoever finds her can claim the ship and everything on her."

"Christ, Captain, this isn't just any derelict. It's gotta be worth a fortune."

"Yeah," I agreed again. "A very large fortune. Under salvage law, a portion of that fortune would go to everyone aboard this ship. The question is, what do we do about it?"

"What do you mean?" a passenger demanded. "If it's worth that much money, claim it!"

"It's not just a hunk of metal," Val replied, her voice deceptively mild. "That is, or was, another ship. A ship whose crew is still aboard, though doubtless long dead. If we board, even just to rig a tow line, it'll be the moral equivalent of digging up gold in a cemetery."

"That's stating it a little strongly," I suggested. "But that is essentially the question. Do we desecrate the final resting place of some of mankind's greatest heroes, those humans who first reached for the stars?"

"I'm against it," Cargo Master Walker declared bluntly. "Leave them alone."

"Are you mad?" Garand blurted. "That derelict is ours for the taking, and worth a fortune to us all!"

"I don't care." Walker glared around,

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finally centering his anger on the space somewhere between me and Garand. "My family has been sailors for generations, on the seas of Earth. Let me tell you, there's a hard-and-fast rule sailors follow. Leave the dead to the sea. No ship, no sailor, ever prospered by disturbing those drowned. It's not right. Let them sleep. I've no wish to awaken their spirits to torment this ship."

A hush fell across the room, the quiet finally broken by Garand's harsh laughter. "Well, I guess science has spoken! Is anyone going to let rank superstition keep them from fame and fortune?"

"That's enough," I rebuked Garand, my tone bringing a flush to his face. "Does anyone else object to boarding the *Odysseus*?"

"I do," Val announced firmly.

"You agree with Walker?"

"No. Yes." Val's mouth worked, then tightened into a thin line. "Those people, the crew of the *Odysseus*, that's their tomb. They shouldn't be disturbed, not because we fear them, but because we respect them. We owe them that."

"You said they've been dead a long time," Doctor Ortega observed.

"Not long enough!" Val shot back, then subsided, embarrassed. "Sorry."

"No problem," I stated softly. "Who was it?"

"My great-grandfather. He served in engineering on the *Odysseus*." Val's eyes, icy with anger, fixed on Garand. "His final resting place deserves to be respected," she repeated.

Doctor Ortega cleared her throat, then spoke softly. "I understand your concern, as well as that of Mr. Walker, but this is far from the first ship to be found after being lost. There was that ship long ago, on one of Earth's oceans, what was the name? The *Titanic*. I read once there was considerable debate on whether the wreck should be disturbed or left as a monument, yet eventually some of the remnants were recovered. Is this not the same thing?"

"No." My flat response drew a raised eyebrow from Ortega. "Wrecks in deep water are different, Doctor. Unless you get to them pretty fast, there aren't any bodies left to desecrate. Everything, flesh and skeleton, disappears pretty quickly in the ocean environment. There weren't any dead left at the site of the *Titanic* when it was found, except in spirit. But a space wreck leaves everything behind, frozen effectively for eternity. We checked the records, and no manned wreck has ever been lost for anything near this long. It's a unique case."

"Besides which," Val added sharply, "military wrecks have always been labeled national war memorials. People never hauled up pieces of sunken military ships because if they had they would have been tossed into jail."

"Was *Odysseus* military?" somebody wondered.

"It had some military personnel on board," Val confirmed.

"That's not the same thing," Garand insisted stubbornly.

"No, it's not." I nodded toward Wata. "Our records indicate *Odysseus* was officially listed as non-military, a peaceful probe of the stars. If it had been government property, we'd still have to worry about an official claim, but public sentiment of the time was such that it was funded by a quasi-private organization. Legally, *Odysseus* is private property, and thus liable to salvage. Since the derelict is still in interstellar space, no other private or governmental authority can dispute possession the way they could if *Odysseus* was in their territory."

Walker jabbed a finger toward me. "So what do you think, Captain? Your vote is the only one that really counts."

"True enough. To be honest, I don't think I want to be remembered as a grave robber, but at the same time I know that our contact with the *Odysseus* has been automatically entered in our ship's official log. I can't tamper with that log, so as soon as we

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reach port a lot of other people will know where *Odysseus* can be found. That'll make it just a matter of time until someone else boards her."

"At least your conscience would be clear," Val stated, with an steely glance toward Garand.

"But what if there're survivors?" Wata wondered.

"Survivors?" Every eye shifted away from me and toward Wata.

"Impossible," Val declared flatly.

"No, not impossible," Wata insisted. "Very unlikely, but if enough crew sacrificed themselves, if everything went right, there might be. We can't rule it out, that one or two descendants of the original crew might have managed to survive this long. We can't leave, not without checking to see if someone is there."

"I'm not sure I'd want to find a survivor," Walker suggested with a shudder. "Alone out here all their lives, with all the things they'd have had to do to survive?"

"They might not be exactly sane," Wata agreed. "But that's not the issue." She turned to me. "Besides, Captain, if we claim *Odysseus* we can ensure she and her crew's remains are treated properly. True grave robbers might just rip everything apart and sell it to the highest bidders."

I thought about it for a moment, keenly aware of the eyes fixed on me. "OK. Wata's right. We do have a responsibility to check out the ship. Beyond that, I reserve the right to leave *Odysseus* in peace or place a claim and take her in tow."

Garand glared at me. "I don't think I care for that. What's wrong with a vote now?"

"The captain just voted," Val replied with a wolfish grin, "and that's the law out here, Mister Garand."

Doctor Ortega struggled with the seals on her suit, finally getting the last one secured. "You ever been on a walk, Doctor?" I asked.

"No, not in space. I trust that is not too great a problem."

"It means you have no bad lessons to unlearn," I assured her. "There's only three hard-and-fast rules on a walk out here. Number One, anytime you're outside, make sure you're fastened securely to something. Number Two, always make sure everyone else knows where you are and what you're doing. Number Three, keep your eyes fixed on the *Odysseus* or our own ship. Don't look away."

She nodded judiciously. "I understand the reasoning behind the first two rules, but why the third? Are not the stars glorious in interstellar space?"

"They are," Val replied in a dry tone. "Doc, humans have a well-developed fear of falling. Near a planet, that's not a problem, because there's something big nearby to fall on and that makes our hind-brains happy. Out here, there's nothing, just the one-and-only bottomless pit to fall through until the crack of doom. People lose their minds staring into it, because there's nothing for those minds to hold onto. Keep your eyes on the ships."

"I will," Ortega promised, paling slightly. She moved toward the airlock hatch, peering at an adjacent viewscreen centered on the nearby hull of the *Odysseus*.

I took advantage of the doctor's preoccupation to sidle close to my Chief Engineer. "Val, are you sure you want to go?" I asked quietly.

"My great-grandfather's over there, Captain. Besides, you'll need a good engineer to look at the condition of the ship."

"It's not the condition of the ship I'm worried about. Look, the crew of the *Odysseus* were lost in the middle of nowhere. The emptiness out here can eat at healthy minds in working ships, and the people on *Odysseus* knew rescue was impossible. God only knows what might have happened."

"You don't think they died heroically?"

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"I don't know. I don't know what we'll find over there. Frankly, I wish someone else was going to see. Maybe they're all sitting at their posts, after working until the end. But it could be very bad. Can you handle that if it is?"

"Captain, contrary to Walker's beliefs, I don't think the dead can hurt us. The only thing we need to fear is what's within ourselves. I'm not afraid of what we might find."

"Good enough." I double-checked my own seals, then led the way into the airlock. "OK," I announced over our suit circuit as the inner hatch cycled closed, "we can see an access hatch on the outside of *Odysseus*. Wata's maneuvered our ship so our own airlock is opposite it. We should have a straight shot." The outer hatch popped softly, revealing *Odysseus*' hull stretching from right to left across our field of vision, framed on top and bottom by strips of black spangled with brilliant stars. Clearly visible against the still-bright hull of the other ship was a large rectangle which should mark the access. I fired a grapnel across, watching as it locked onto the other ship next to the access, then led the way hand-over-hand. I reached one hand out tentatively, my suited fingers finally brushing against the metal of a ship out of legend.

"Unbelievable," Val whispered. I turned and saw she was also gazing at the *Odysseus* with something born of disbelief and wonder. A moment later, she tore her eyes away to focus on the nearest portion of the hull. "This looks like the control panel," she noted, prying at a half-meter square panel. It resisted her efforts, frozen by time and space, until a tool forced it open.

"Will that still work?" I wondered.

Val grinned, though with tension, not humor, as she punched a series of buttons. "If not, I'll run a power cable from our ship. It looks operational, though." After a moment, I felt a lurch through the *Odysseus*' hull, followed by the smooth opening of the access hatch. "Bingo, Captain."

"Thanks." I led the way again, fighting down a feeling of intruding where I shouldn't be. The clean technology of the airlock clashed incongruously with my mental vision of penetrating an ancient burial mound. Val and Doctor Ortega hung close to me as the outer hatch sealed and the airlock began compressing. My right hand swung down to caress the holster where my sidearm rested, a rarely-used weapon usually safely sealed in the ship's safe, intended more for show than action. Memory of Wata's speculation of a survivor, and what condition such a survivor's mind might be in, moved me to free the seals on the holster. My hand closed on the weapon's grip as the inner hatch swung open with a soft sigh audible on our exterior mikes.

I'd prepared myself for a variety of sights when the interior hatch swung open, but none matched what met my eyes. An immaculate, empty passageway ran off in two directions, its dimensions obvious in the low illumination provided by glowing light fixtures at regular intervals. Occasionally, a dimmer gap showed where a fixture had failed, but otherwise the inside of the *Odysseus* seemed ready for inspection.

"There's still plenty of power." I didn't attempt to hide my surprise.

Val jerked her head to indicate aft. "They outfitted this thing with enough nuclear material to provide energy for a millennium, if it's properly rationed."

"I read plenty of atmosphere."

Doctor Ortega nodded, squinting at her read-outs. "Yes, Captain. Pressure is a little below standard, but not much. Unfortunately, it has a fairly high CO_2 component and appears to be very stale."

"Stale?"

"Yes. The air in this section of the *Odysseus*, at least, has not circulated for a very long time. I would not attempt to breathe it. I also would not care to smell it."

"Noted. We won't try."

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Ortega peered forward and aft down the passageway. "Very tidy. It appears we can rule out hysteria, panic or insanity."

"Maybe." I reached out and began to swing forward. "Let's check the bridge."

As I'd guessed, the large passageway led through a major bulkhead, then dead-ended at another. Following the cross-passage, empty of bodies or debris like its counterpart, my little boarding party soon reached a hatch with "Bridge—Authorized Personnel Only" spelled out in the blocky text spaceships had inherited from their seagoing ancestors. My right hand nervously patted my side-arm even as my left punched the hatch access control.

It cycled open with a deliberation which suggested resentment to my heightened senses. Biting my lower lip, I leaned in, taking in the entire bridge with one glance. "Empty."

Val followed, crowding me in the access. "I thought we'd find the Captain here, for sure."

"Me, too. This is getting spooky." All the stations were clearly labeled, making it easy to single out the command seat. "Val, can I access the captain's log from here?"

"Should be able to." She studied the controls for a moment, punched in some commands, scowled, punched some more, then smiled triumphantly. "There you are. Since there's atmosphere, I set it to normal sound playback. We should pick that up easily on our external mikes. What do you want to hear?"

"All of it, but that'll have to wait. Give us the last entry."

Val punched again, then waited. Moments later, the *Odysseus*'s captain spoke to us from the past. His voice was harsh, each grim detail coming in words spaced as steadily and heavily as the footfalls of someone headed for their execution. "Chief Engineer Kurosawa confirms our worst fears. Even though we had the means to fabricate a replacement Umbari Coil, the failure of the first coil resulted in the destruction of the rest of the Trans-Light Drive mechanism, as well as numerous associated systems. The last month of effort, futile effort unfortunately, served only to prove that repair, to put it bluntly, is impossible. The power plant remains functional, and in a cruel irony *Odysseus* remains on course for our objective. Unfortunately, at the speed we are condemned to travel we will not reach that star for centuries. The same is true of any attempt to return home. Life support will not function long enough, even for a drastically reduced crew. I have called a meeting with all hands to discuss our options."

I kept waiting for several seconds after the voice stopped, sure that it would continue. "Val, where's the rest?"

"That's all there is," she confirmed. "Last entry, in full."

Doctor Ortega tried to scratch her head, flinching in surprise as her gloved hand instead rebounded off her suit helmet. "I would have expected the captain to leave some final message. Perhaps something happened during this meeting?"

"Perhaps. Let's go."

There's a certain consistent logic to the interior layouts of most ships. Given a need to fit a certain number of spaces with a certain number of functions within a limited area, designs usually ended up following the same relatively efficient patterns. The mess deck turned up about where I thought it should be. Unfortunately, it proved as empty as everywhere else. "Where the hell are they?" I muttered angrily. "That meeting the captain referred to had to take place here, and he didn't leave any more log entries."

"Apparently he chose not to," Val noted. "Captain, why don't we check some of the cabins?"

"I guess we have to," I agreed reluctantly. "I don't mind telling you that if we don't find anybody in those, I'm going to be really upset."

I needn't have worried. The first cab-

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in we checked turned out to be occupied. "I never thought I'd be so happy to see dead humans."

The bodies had been mummified in the dry, sterile environment, so that peaceful expressions were still apparent. Crossed arms rested over their upper bodies, reinforcing the impression of ancient pharaohs somehow clothed in the garb of Third Millennium space explorers. Ortega leaned over to nudge a small container floating near one bunk, bringing its label into view. "Barbiturates," she announced. "A lethal dose for each, no doubt."

"Suicide," Val sighed. "Perhaps the best option left them." She fingered a sheaf of paper lying nearby, then smiled at me with humorless triumph. "Farewell message, right here."

"They wrote them out?"

"Sure." Val carefully returned the papers to their original configuration. "They had no idea how long it might be before they were found. Any automated storage media might deteriorate in the interval, especially if power failed and let radiation sleet through the ship. But paper would last a very long time in this kind of environment."

"That makes sense. I guess they thought it out beforehand."

"Exactly." Val turned to leave the cabin. "No panic. No insanity. They left this life calmly. Heroically."

"Some of them did," I agreed.

"Some of them?"

I pointed one finger toward the fourth bunk in the cabin. "Where's the other roommate?"

Val stared, her thoughts running across her face too fast to read. "Perhaps at his or her work station," she finally suggested.

"Every work station we've seen so far has been empty. But you might be right. Let's find out." We made our way from cabin to cabin, the repetitive tragedy of the vignettes within rapidly dulling our senses. Outside the last, I tried unsuccessfully to rub my neck through the helmet seal. "We're missing three bodies, people."

"Work stations," Val repeated stubbornly.

"That's a lot of territory to check, and we're going to do it really carefully."

"Why?" she snapped, then bit her lip. "Sorry, Captain."

"That's okay. I'm glad we found your great-grandfather, but it can't have been pleasant for you. Walker may be right. I don't like disturbing these people's rest."

"Then why keep looking?" Val demanded.

"Because the three missing crew might have decided to end it all at their work stations, or they might have changed their minds. Maybe tried to live, maybe went a little over the bend after a while. Or a lot. We don't know what they might have left behind."

Ortega nodded. "Like the genie in the bottle. You know, in the original story the genie begged to be released but then declared his intention of killing the one who had released it. After waiting so long for rescue, it had become consumed with hatred. This could happen to a human, lost out here with no rescue ever coming."

Val looked around slowly, eyes narrowing. "Booby-traps, maybe? A self-destruct sequence rigged to our entry?"

"Can't rule it out. Doc, is there a quicker way to find those last three than checking every compartment and maybe tripping a bomb?"

Ortega spread her hands in apology. "Alas, no, Captain, not with what we have. A building scanner might do, but such are designed to locate living people within collapsed structures, and in any event we do not have one." Her face brightened suddenly. "Wait! The crew might have been equipped with implants to monitor their health and locations during exploration activity. If so, the sick-bay may contain a panel allowing us to pinpoint them."

"Great. Let's find it."

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Painted arrows beneath the ancient sign of the red cross led us to a nearby hatch. Ortega pushed confidently through, then froze in mid-push. "Captain?"

"Yeah." The sidearm was in my hand, though I had no idea what it could do against a trap set centuries before. "What is it?"

"We have found your missing crew." She slid carefully to one side so I could see within. The hand holding my useless weapon drifted unheeded as I stared.

Three bodies floated within, so thin as to be almost skeletal, long strands of white hair drifting in gentle air currents. "There's circulation in here," I suddenly realized. "Val, seal the hatch!"

Ortega moved carefully around the figures, one forefinger tracing tubes leading into shrunken limbs, then pausing to rest against one of the small cushions on the loose frameworks surrounding each body. "Silk," she announced.

"What the hell is this?" I breathed the question. "What were they doing?"

"Staying alive," Doctor Ortega stated. "You see? A slow, steady nutrient feed, waste removal tubes, and the bodies set within an environment of absolutely minimal strain. They have simply drifted here, conserving life as best any human body can given severely limited food supplies. This area, and probably only this area, received fresh oxygen and had CO_2 scrubbed from the air. They sought to maximize the duration of their life support as well." She pointed to screens positioned above each figure's head, one still flickering with constant gray static. "Even entertainment, once. Perhaps voice activated. At some point, no doubt, the isolation and inactivity still overcame their senses. It must have been a horrible experience."

"But why?" I moved closer, repelled and fascinated by the emaciated, drifting figures. "What was the point? Why die like this instead of with some degree of dignity?"

"Die?" Ortega shook her finger at me. "One, yes. But the other two still live, Captain. There is respiration. There is circulation. There is brain activity. They still live."

"So that's it. Doctor Ortega says the two crew still living can't be moved by us without killing them. Accelerating or decelerating *Odysseus* would also kill them."

My audience, crew and passengers again gathered in my ship, exchanged glances. "It sounds as if that would be a mercy," Garand noted stubbornly.

"It might be," I admitted. "It might also be murder."

"As a rule," Doctor Ortega added, "any action taken with such fragile lives must be with the aim of aiding them. Something certain to cause death instead would not be lawful. Not without their consent, and such cannot be acquired while they remain comatose."

"So we can't move the *Odysseus*," one of my crew noted, "but we can still claim it, right?"

"I guess so." I grimaced as I replied, meeting the eyes of my crew. "I'm still not sure that's the right thing to do."

"If we don't do it, someone else will," Garand stated brusquely. "You won't be preventing harm to the derelict, you'll just be giving someone with perhaps fewer scruples the chance to rape it instead."

"And you'll be robbing everyone on this ship of their share in the wealth that claiming this wreck will bring," one of my engineers noted, flinching as Val turned a withering glance on him.

"The ship and crew which found the legendary *Odysseus* will themselves be somewhat famous," Doctor Ortega observed. "That will surely translate into some degree of wealth for those so inclined to exploit that fame."

"That won't be any damn fortune," someone grumped.

"Probably not," I conceded. "In any case, I don't know what choice I have. If I don't claim *Odysseus*, someone else will."

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"No, they won't." First Officer Watabayashi, standing in the entry, shook her head as everyone's attention focused on her. "Boss, I just finished checking something I suspected as soon as you found those two crew members. We can't claim the *Odysseus*, and neither we nor anyone else can loot it. Once we make our report, a government ship will come to guard it as fast as it can get here."

"Explain, Wata. What difference do two near-corpses make?"

"*Near*-corpses," she emphasized. "Don't you realize what their presence means, boss? Part of the crew of *Odysseus* is still alive, which means the ship was never abandoned, which means legally it's not a derelict."

"So who's it belong to?" Val demanded.

"I checked. The quasi-private organization which launched *Odysseus* went belly-up after the failure. Its assets were eventually all absorbed by its government. Hence, *Odysseus* belongs to that government." She bent a polite but insincere smile toward Garand. "Sorry, everybody. Legally, we have no claim, and the only money associated with *Odysseus* is whatever finder's fee the government might offer."

My cabin had precious little in the way of space, but it did have privacy and room for another chair. Wata sat strapped in there, gazing toward the bulkhead as if she could see through it and the Umbari distortion to where *Odysseus,* now far behind us, plowed with steadfast stubbornness through normal space toward her far-off destination. "What's up, boss?" she finally asked.

"I just wanted to thank you, for finding out that *Odysseus*' legal status had changed, and for telling us."

Wata smiled, shaking her head. "Thank me? Knowing is my job, and as for telling, what else was I supposed to do?"

I grinned back, mentally at peace for the first time since we'd found the lost ship. "You could have kept quiet long enough for us to pull stuff off *Odysseus*, enough 'souvenirs' to generate a small but tidy fortune on the black market."

"Wrong, boss. I couldn't have kept quiet. I have friends who've died in wrecks, just like any other sailor does. I never knew those people on *Odysseus*, but we're brothers and sisters under the skin." Her gaze switched back to the bulkhead. "I'm glad we didn't take anything off that ship."

"We took something." I waved toward my personal safe, ignoring Wata's sudden look of surprise and disapproval. "Val picked up the last message written by her great-grandfather. It's hers. She asked me to keep it here where it'd be safe."

"Did you read it?"

"No. It's not addressed to me. I did read a couple, but not that one."

Wata hesitated, staring at me in puzzlement. "You read some?"

"Yeah. The captain's, because I wanted to know how he handled the worst crisis any captain can face."

"One isn't some."

"No. I also read the messages left by the ones who lived."

"So why'd they do it?" Wata shivered. "I'm going to have nightmares, boss, just thinking about what they endured."

"Then don't think about it," I advised. "It turns out they did it partly for exactly the reason they needed to; to ensure the *Odysseus* wasn't legally abandoned. I guess Earth was in the midst of a fairly *laissez-faire* period when they left, and they figured if someone didn't try to stay alive to look out for the others then all their bodies might get carved into pieces and sold for knickknacks or something."

"Good guess."

"That wasn't the only reason, of course." My expression shifted into admiration. "They didn't want to give up short of their goal. After calculating the resources available they figured by

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stretching everything to the max they might just be able to keep three people alive long enough to reach that star. They'd have to live an extraordinarily long time, but with zero strain on the bodies it might happen."

Wata stared. "The Universe screwed them and they wanted to see if they could still beat it, eh? Tough bunch of sailors."

"Tough is one word for it. They wouldn't quit, even though it meant three of them had to be condemned to a living hell." I shook my head, eyes downcast. "I can't even imagine the courage it took to volunteer for that, to endure that."

Wata nodded somberly. "I'm ashamed to say that when I first heard about the survivors I thought they'd been afraid to die, that they'd tried desperately to live simply out of fear."

"Yeah, that thought crossed my mind, too. We tend to measure human courage in terms of willingness to die, forgetting that sometimes dying is the easier way out. Staying alive, despite the odds, despite the pain, is sometimes the bravest thing any human can manage."

Wata smiled wryly. "True, boss, but that kind of attitude is kind of crazy, don't you think?"

"Crazy? Yeah. No far-future historian will ever accuse *Homo sapiens* of being totally rational." I thought about the eternal night and distant, unfeeling stars outside our ship's hull. "But that crazy attitude has taken our species further than we imagined possible, and it'll take us further yet." I pulled two rum rations out and offered one to Wata before hoisting my own in a toast. "So, here's to living heroes." □

IN TIMES TO COME

The lead novelette in our March issue will be "Elephants' Graveyard," by David Alexander and Hayford Peirce, wherein former senior facilitator Isaiah Howe has to figure out a decidedly peculiar—and occasionally lethal—relationship among an uncertain number of species of beings. None of them are elephants, actually, but the significance of the title eventually becomes clear enough, and gives Isaiah a unique chance to apply the skills of his old trade. (Some readers will recognize connections to the earlier tale of Isaiah, "Finder's Fee," in our April 1998 issue—but of course that is *not* a prerequisite for enjoying the new story!)

Our other fiction includes a novelette by a well-known writer new to these pages, Kristine Kathryn Rusch, and stories by Rick Cook, Sarah Zettel, Michael F. Flynn, and Shane M. Tourtellotte.

Finally, Jeff Hecht's science fact article on "The Lost Generation of Fiber Optics" is an intriguing case study in how science turns into widely used technology. We now take fiber optics for granted in a wide range of applications, but the path from the underlying discoveries to the present situation was not quick, smooth, or easy. Sometimes the seeds of a new technology are laid down before the technological and sociological soil is ready for them to grow, and must wait for appropriate rains to fall. . . .

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THE MARINOV MOTOR AND ME PART I

While I was researching my fact article "Paradigm Shifty Things" (June, '97), I thought I was hip-deep in the world of weird science. How wrong I was. After that piece appeared, I got letters, many of them from folks who really were deeply involved in the weird science world, and this led to me taking the genuine plunge myself. What kind of plunge? Well, basement experimentation, for one thing; writing my own scientific papers, disclosing anomalous results, etc.

Mind you, I had not intended to do this. I thought I'd just write the occasional fact article, but continue to devote my time to fiction and leave the weird science stuff as delightful leisure-time reading, a source of pleasure and story ideas.

But Dr. Phipps sent a paper to me written by Wesley which explained an anomalous motor built by some Stefan Marinov, and I passed the paper on to Tom Ligon, who figured out a simple way to study the motor, and then. . . .

Let me start with Marinov. The guy was nuts. He was not nuts because his ideas for paradigm shifty physics were unbelievable. No, indeed, by the time you reach the end of part two of this Alternate View you also will suspect something is amiss with how we treat electromagnetic theory in our textbooks. But anyone who threatens to burn himself up unless a journal publishes his paper, which Marinov did, has a problem. Still, though nuts, he was brilliant.

Marinov had made himself a motor which he called his "Siberian Coliu." This motor was supposed to "self-accelerate," that is, violate the law of energy conservation, for reasons too obscure to go into. The motor didn't work as he'd expected, and in the end, Marinov committed suicide.

Shortly after Marinov's death, J. P. Wesley wrote a paper entitled: "The Marinov Motor: Induction With No **B** Field." It was Wesley who called the Siberian Coliu the "Marinov Motor" for the first time, and Ligon's superior version of the illustration of the motor that appeared in Wesley's paper appears here. Wesley claimed that Marinov's motor, though not guilty of energy conservation violation, did, in fact, demonstrate certain inadequacies with fundamental E&M theory. (The nature of those inadequacies I will explain below.)

At this point, let's inspect the diagram. Shown is what is supposed to be a "flux-enclosing" rectangular torus; that is, the magnetic field is entirely contained within the torus. The field outside the torus, the **B** field (for purists, yes, I know there is a difference between the *magnetic field* and the *magnetic induction*—transliterate as need be), is identically equal to zero. It is asserted that the ring shown, if current is introduced via brushes and the ring is free to rotate, *will* rotate. Think about that for a minute. We have a torus with no field outside of it, and a ring around this that does nothing but split up a current into two paths and then recombine that current on the other side of the torus, and this ring is supposed to rotate. Weird, huh? Couldn't possibly work, huh?

In any analysis of a conventional motor, saying that there is no magnetic field present is the same as saying nothing is going to happen. There are accepted experiments, though, where such "field-free"

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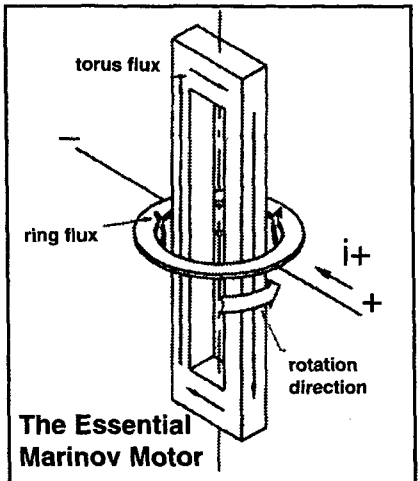

(Illustration courtesy Tom Ligon, Assorted Technical Expertise)

regions *do* have effects one wouldn't ordinarily expect, and the reader is encouraged to look up the "Aharonov-Bohm effect."[1]

Just looking at the torus suggests several ways one could fashion one for himself and do some home experimentation. You could take two horseshoe magnets and put the opposite poles together. You could also take two long bar magnets and connect them together by soft iron keepers top and bottom, or two short bar magnets connected by long keepers that pass through the ring. So long as the "flux sense direction" remains the same you're going to be approximating the torus reasonably well, at least well enough to see if anything will happen at all.

How to "float" that ring? This was a major sticking point for those very few people other than Marinov who had any interest in this device. Ligon simply decided to reverse the motor. Instead of having a ring free to turn, he fixed the ring and dangled the torus from a wire. Upon application of current, the torus twisted briskly. Well, any idiot could do this, so of course, I tried it immediately. I, too, got the torus to turn.

Now, an important note. In the situation where the torus turns and the ring is fixed, the torus's null position is at ninety degrees from its starting position. After it starts to turn, once it passes ninety degrees, it feels a reversed polarity from the starting position, which would make it turn in the other direction. With current applied, after awhile the torus will settle down at the one-quarter-turn spot. But when the ring is free to rotate, the ring is supposed to do so continuously.

One thing you find out rather quickly is that it's not easy to make a torus that entirely contains its field. In fact, it's darn difficult. So critics rightly can point out that the turning is entirely due to leakage from the magnets—in short, there *is* a magnetic field present, and that is what's causing the effects.

Fair enough. How?

One item all beginning physics and engineering students learn in intro E&M is the equation for the force on a current-carrying wire in the presence of a magnetic field. Assuming there are no electric fields present, this equation is:

$\mathbf{F} = i\mathbf{L} \times \mathbf{B}$. The boldface indicates that F, L, and B are vectors, and the "x" is not a multiplication sign but a cross-product symbol. For those of you with eyes glazing over at the math, I'll keep this short. Assuming that the wire is at right angles to the magnetic field, the force (F) is equal to the current (i) times the length of the wire (L) immersed in the magnetic field (B), times the strength of that field. The direction of the force is at right angles to both the direction of the wire and the direction of the field. A simple way to remember this is to use the "right-hand-rule." If we define the current direction as going from positive to negative (this is called traditional current), then if you point the thumb of your right hand in the direction of the current, and the fingers of your hand in the direction of the field, the direction of the force on the wire will point straight out of your palm.

When you apply the right-hand-rule to the Marinov Motor ring, however, you start to notice the problem for regular engineering physics—that is, there is no force acting to make the ring turn. Look at the figure again and assume you made

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yourself a torus out of two long bar magnets connected top and bottom with soft iron keepers. Also, assume that what goes on inside the torus is meaningless and the critics are right—the leakage field is what makes the motor go. Considering the figure, on the near side you'd have a bar magnet with its S end up, so the magnetic flux lines would be coming out of the bottom, passing upward through the ring at the point where the current enters, and reentering the bar magnet on the top.

Now consider the situation in the nearest quadrant, just to the left of where the current enters. The current is flowing to the left, so stick the thumb of your right hand in that direction. The field is directed upward, so point your fingers that way. The force is directed *inward* toward the torus, not tangentially to make the ring rotate.

If you repeat this procedure all the way around the ring, you'll soon find that two quadrants on opposite sides of the torus have resultant forces pointing inward, and two quadrants have resulting forces pointing outward. So even if one assumes up front that the cause of ring rotation lies with the fields interacting with ring current in a straightforward way, he immediately finds himself up the creek.

Truncating a lot of history and missteps, I personally was not content to just make a torus turn. I wanted to see a ring rotate, and after a while I did manage to make one go around. This was a neat thing to see because the ring does rotate continuously—there are no dead spots for it. My early attempts were jerky and difficult—dead shorting a battery through a copper ring leads to spot welds and fouling. But, by golly, I proved that the darn thing works.

Phipps, Ligon, and I thought we were on our way, that we would understand this motor soon, and that it indeed pointed to a serious deficiency in ordinary electromagnetic theory. That classical electromagnetism has problems is old news. But such a big error that it can't even predict the behavior of something as easy to build as a Marinov Motor? This was exciting stuff!

Still, there were flies in the ointment. For one thing, we never could get our motors to turn the way Wesley's theory said they should. For instance, if you take the simple rectangular torus shown, and make one with two bar magnets going through the ring and keepers top and bottom, it will initially turn in the opposite direction from a torus made with the magnets on the top and bottom and steel bars projecting through the ring. In short, even though you can keep the internal flux sense the same, the torus will reverse its sense of rotation.

This observation led me to finally discard the "non-magnet" parts of my toroids completely. Since I was deliberately working with leakage fields anyway, why bother to contain them at all? This proved a valuable thing to do since it forced me to consider the magnets themselves as the "power units" of the toroids, and to work out a theory of operation that accounted for the reversals that would happen despite the preservation of flux-sense direction. It also allowed me to make some very simple, brushless DC motors which you will not find in any book on electrical machinery.

But the devil remained in the details, and that will be the subject of part two.

Those of you who want to write, please wait until you've seen the next installment. I'll talk about the criticisms, conventional explanations, etc., that came over. There were many of them and I'd rather you potential writers see what's already been discussed so you can bring up something new rather than going over old ground. Because, you see, the Marinov motor did something so spooky that it left me speechless. And that's damn hard to do! □

Reference

1. Y. Aharanov and D. Bohm, "Significance of Electromagnetic Potentials in the Quantum Theory," *Phys. Rev. 115*, No. 3, 485 (1959).

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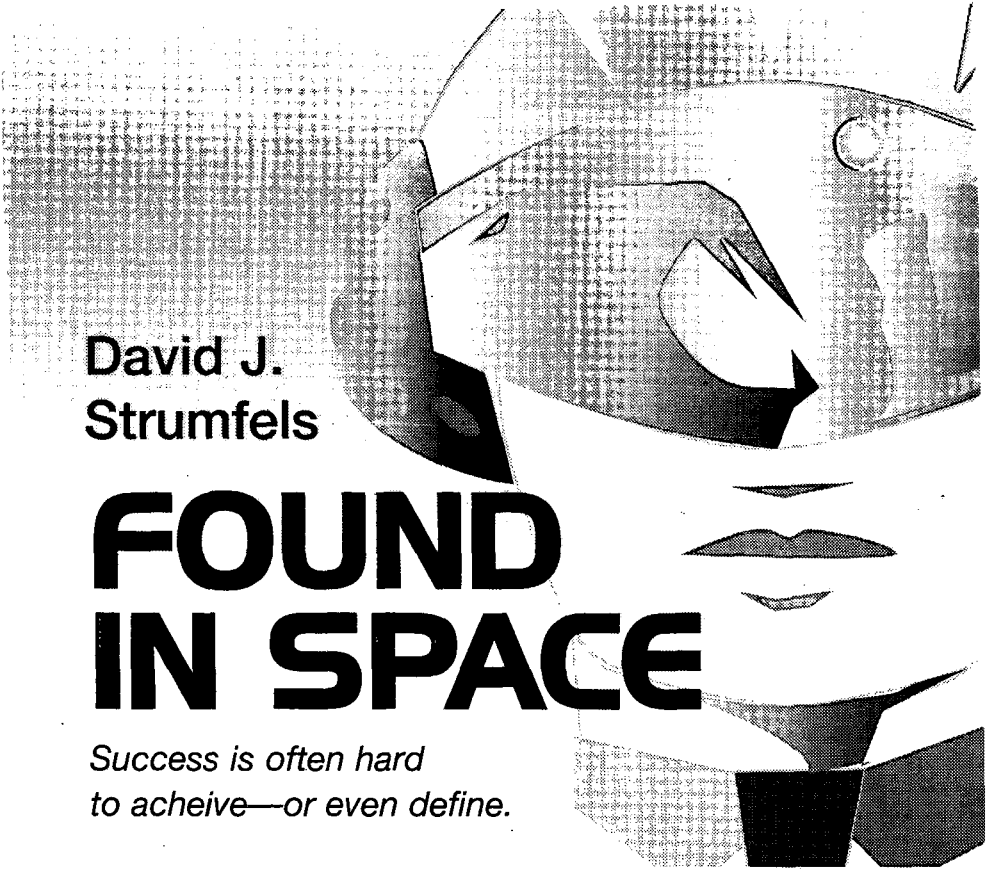

David J. Strumfels

FOUND IN SPACE

Success is often hard to acheive—or even define.

"Warning! Warning! Danger! Danger!"

Zed spun around just in time to see the huge Antarean carnivore bearing down on him. Whipping out his laser pistol, he zapped the hairy beast into disintegrated nothingness just as it was about to sink its six-inch fangs into him. Another second and . . . even so, he stumbled backwards from the flash, tripped over a rock, and landed painfully on his coccyx.

"Are you unharmed, Dr. Jones?"

"Dazed, but—" he got up and rubbed the unfortunate part of his body, "otherwise in one piece. Thanks, Jeeves; I would never have seen that thing coming if it weren't for you."

"Merely one of my many functions," the robot replied, in sincere modesty. "And now we should get back to looking for dilithium ore for our . . ."

"There's only one thing I don't understand," Zed interrupted the unnecessary reminder. He examined the queasy feeling he'd had ever since they'd crash landed on this desolate planet, finally found what was bothering him. "Well, this is Antarean Four, right?"

"That is correct, Dr. Jones. The fourth planet circling . . ."

"But Antares is a red supergiant star. It couldn't possibly have life on any of its planets, even assuming it could have terrestrial planets with oxygen atmospheres, which is highly doubtful. And now that I've mentioned it, I haven't seen a single plant on this rock ever since we landed four months ago. You need plants to make oxygen, don't you?

"And another thing," he pressed, on a roll now. "A laser gun wouldn't disintegrate something as large as that creature. And even if it did, the blast would have

Illustration by Shirley Chan

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taken me—both of us, as a matter of fact—with it. Yet we're both still standing here, in good shape." He rubbed his rear end; well, not perfect shape, but a lot better than he should have been in. "There's something terribly wrong with all of this, don't you think, Jeeves? Jeeves?"

"That does not compute," his mechanical companion answered. "Perhaps if you beamed yourself back aboard the Uranus III the main computer can help you. . . ."

"Beamed myself? *Beamed* myself? That's another thing. How the hell can an object the size of an adult human being be converted into energy, 'beamed' anywhere, and then reassembled back to its original form? The information storage it would take to do that is magnitudes of order beyond anything remotely foreseeable.

"Jeeves," Zed concluded, "Something is seriously wrong here. And I intend to find out what it is. And fix it."

"What's seriously wrong is that it's all horseshit. There isn't an ounce of real science in the program at all. It's all just razzle and dazzle and special effects. I thought you people were supposed to be doing science fiction, not this—this—this garbage."

Zed resisted the impulse to slam the virtual reality helmet to the ground, and instead carefully returned it to its holder. Then he got up and started pacing furiously. He was careful to bite his tongue on most of what he wanted to say. Finally, he composed himself sufficiently to continue. "Look. This won't cut it. It's all perfectly well and good to speculate on what might be possible, but that doesn't mean anything goes. You can't throw out everything we do know just to get a product out the door. Besides, even the average John Q. Public isn't that stupid. If I could pick out what was wrong with that sim, so can he."

"But . . ."

Zed faced the source of the interruption with his hardest glare. Bernie Malone didn't wilt under it, however. "We've already subjected that particular sim to Audience Analysis Testing. The stats show the target market hitting some of our highest acceptance levels ever. We'd be crazy to mess with it now."

In other words, John Q. Public *was* that stupid. Zed looked around his office, and saw nothing but agreement. Worse, if the AAT passed it, that was going to carry a lot of weight with marketing. Which meant he had about as much chance of changing the scriptware now as—well, as Antares had of harboring planets with hairy monsters. And the faces before him, nominally his subordinates, knew it.

"All right then, get out of here and get back to work. For God's sake though, next time do a little research before you start on the script. It sure as hell can't hurt to get some things right; who knows, we might even pick up a few serious SF fans." *Who might even have some decent ideas*, he thought to himself.

When they'd left, he turned and faced the gibbous earth outside his office window. For once, the bright blue glow filled him with nothing but melancholy. You would have thought that getting into space would make the average person more knowledgeable about what lay beyond that thin envelope covering his homeworld. Knowledgeable and critical; especially now that being stupid and/or unthinking could quickly cost you your life, not to mention the lives of those around you. But if what his simwriters were telling him was true, the reverse was happening: people were becoming so accustomed to the idea of living within centimeters of deadly vacuums and radiation and other killers that their critical senses had actually been dulled.

Could it be true? Zed shook his head. He certainly didn't want to think so. But if it were so, he might not have any

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choice: as Director of Programming it was his job to see that the scriptware his writers churned out would produce the maximum profit for the company. And if he didn't like that job description, well . . . there were others waiting to take his place.

The chirp on his deskpad broke his train of thought. He touched a spot on the screen to end the irritating sound. "Yes?"

The face that appeared was not a happy one, not that Alicia Wu-McAuliffe ever looked particularly cheerful. Still, her voice was pleasant enough. "Hello, Zed. Would you mind stopping by my office for a few minutes? There's something I'd like to chat about."

Zed knew, of course, what that something was. Disgruntled writers don't waste time going over their immediate superiors' heads, he'd noticed. Unfortunately, there was no easy way out of what was coming; none he could think of on the spur of the moment, anyway. "Sure. I'm on my way." He even managed a grin when he said it.

It was not returned.

Six years of schooling wasted, he decided.

And he'd worked so hard for it, too. A double major in theater and modern lit, with a minor in astrophysics. His deans, counselors, professors, and friends had all thought him nuts. And now, finally, he was beginning to concede they were right. His was a lost life; in fact, he could even recall one of his professors using just those words to describe his likely career.

It had started off promising, though. The sims he'd edited for that first small, struggling company he'd worked for had gone over quite well—better than anyone had expected. Too bad they'd gone under; Zed was starting to think he might have been happy, spending a lifetime in that small but cozy office, paltry income notwithstanding. Certainly none of the big houses were going to be interested in a maverick who believed that Science was as important a component of SF sims as Fiction. They were simply out to make the biggest bucks possible, and to hell with whether anyone learned anything accurate or useful.

At least that was what he'd believed, until the call from McAuliffe Publications came. Was he interested in a position directing their SF division? they'd asked. He'd been so dumbfounded at the suggestion that he almost told them he'd get back to them on it, but fortunately caught himself in time and set up an interview right then and there. Then the most amazing thing of all: they offered him the position. He couldn't believe it. It was as though some angel had dropped in on him out of heaven—on some off day, perhaps—and decided to bestow a medal on this one, poor mortal soul. It did seem a miracle.

A miracle he had the bad feeling was about to clock out.

Wu-McAuliffe's office was two levels above his, a modest but noticeable change in angular momentum, and hence apparent weight, which still took a moment to adjust to. Zed had seen newcomers to the station become seriously disoriented when they stepped off the lift and found their bodies not working quite the same they'd been a few moments before; lurches and stumbles were common for the first few days, and more than one bone had been broken during the learning process. Everyone learned pretty much the hard way.

He passed the emergency exit, barely noticing the green light that indicated—one assumed—that the locks were secured and in proper working condition, then he circumvented one of the bulkheads separating the main living area from the core, where the fusion of lunar-supplied deuterium and helium three powered the station, and ignored the friendly waves of EVA workers repairing something outside a viewing port.

"Come in, Zed," Wu-McAuliffe's voice replied to his touch on her door.

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"I hear you're not happy with some of your people's material," she said, once he'd seated himself and been helped to a cup of tea. "What seems to be the problem?"

He didn't see any reason for evasion, as both of them knew exactly what the problem was, and that he wasn't really here to discuss it. Nevertheless, he tried. "I'm worried about some of our scripts," he said. "Frankly, the research that has gone into them is . . . well, to put it mildly, less than satisfying. For example—" He relayed his experience with the Antarean scene. "You can see, it's not very realistic. I mean, even when Antares was on the Main Sequence, it wouldn't have stayed there long enough for complex life forms to evolve on any planets; and even if there were enough time, the intense stellar wind from a star of that mass and luminosity would make it chemically impossible. Now, I know that most of our customers probably don't know that, but some will; and those are customers we won't make a second sale to."

"I see." Wu-McAuliffe was stippling her fingers, tapping them together impatiently. Zed realized that she probably hadn't a clue what the Main Sequence was, and probably didn't care. "Well, Dr. Jones," she said after a few moments' thought, "what would you propose doing to correct this flaw? Without affecting those elements of the script which results in its excellent stats, that is?"

The question caught Zed off-guard; he'd been expecting something more along the lines of a polite but firm reminder of what his job was, the consequences of his not doing it properly, and a curt dismissal from her office. The last thing he'd thought he'd be facing was even the pretense of a serious discussion of his concerns.

As a result, it took him several seconds to formulate any kind of reply. "Well, er, um—well, for one thing, we could—" he realized he should have said should, but it was too late now—"put the ship on a planet orbiting a more plausible star. Such as . . . as . . . oh Tau Ceti comes to mind; we know that has at least one terrestrial planet that could be Earth-like, based on the more recent long range optical interferometry data . . ."

"Tau Ceti?" Wu-McAuliffe interrupted him. "*Tau Ceti?* You want our castaways stranded on a planet circling a star called Tau Ceti?" The name sounded even uglier issuing from her lips than it did in Zed's mind.

Zed felt himself reddening at the obvious sarcasm. "It is one of the few candidates we have for Earth-like terrestrial worlds. I think it would make an excellent choice."

His boss closed her eyes for a moment. "Dr. Jones, can you imagine the typical customer's reaction to being attacked by a Tau Cetian monster? Doesn't exactly sound like something that could rip your entrails out in a second if you don't take heroic action, does it? Now an Antarean, on the other hand . . ." Her face reflected the poetry of the word as much as her voice.

"But that's scientifically absurd!" He found himself getting hot around the collar; not a good idea, but his patience was wearing thin. Didn't anyone care about getting facts right?

"You're missing my point. It doesn't matter what star it actually is. Make it a realistic Earth-like planet, if you want. My point is, it has to sound good. For God's sake, make up the name if you have to. You are allowed to use your imagination, you know."

Once again, Zed found himself facing an unexpected reaction. And once again, he had to compose his thoughts. "Wait a minute. Let me get this straight: I can change the star to something that makes sense, as long as I come up with a good name for it?"

"You have writers to make up things like names," Wu-McAuliffe reminded him. "But to answer your question—no, I have no problems with that."

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Zed was beginning to feel, well, whatever it was, it was a pleasant feeling. One that, as unexpected as it was, suddenly gave him the confidence to push forward some of this other objections. "There's also this problem with 'beaming' people around. Look, I know the special effects are very pretty, but that kind of transportation technology is impossible for several reasons. We've got to come up with a different way of getting people around. Besides," he added quickly, "it makes things too easy. Our characters are constantly beaming their way out of tight situations. You could get a lot more drama if they had to escape the old-fashioned way, using their wits and what resources they found on hand. If you ask me, that would more than make up for what you'd lose in special effects."

Wu-McAuliffe caressed her chin. "Interesting. I see your point; frankly, it hadn't occurred to me. It would make things a lot more interesting, now that I think about it." She grinned wickedly. "Sounds as though you really want to make your writers earn their pay, Dr. Jones. Hmm, well I for one have no objections to that either." She paused for a moment's consideration. "Tell you what. Come back to me in a week with the changes you've suggested, and any others you think necessary. We'll run it through the AAT again, and see where the stats come out."

"Really? Uh, that is, yes, WM. I'll have those changes on your desk, and the analysis, within a week. Is there, ah, anything else you want?"

"No. That will be all for now. Thank you for coming, Dr. Jones. I appreciate your input into these matters. Good day."

Zed was so ecstatic he could barely contain his emotions. She was actually taking his concerns seriously! "Thank you." He retreated from this office before saying anything that might change her mind. Only when the door was shut in front of him again did he let his breath out.

And this time he waved at the workers through the port window.

He'd barely finished waving when the klaxons sounded.

At first he didn't know what they were telling him. Nor did he care, for only two parts of his brain were functioning: the one that was shrieking at him to get away from where he was, to run, hide, to just *get the hell OUT OF HERE!!* And the other that was frozen like a fawn in the grass, amidst the bellowing roar of lions. Both of which were in control for at most perhaps two seconds before his training and rationality crawled back into control and told him what the mad, flashing red lights on the walls around him had been screaming at him all along.

Then there was another panic, this time far worse for it was from without. Wild, panic-locked faces raced by him in the halls, their lips bubbling saliva and issuing oaths, some silent and reverent, others tearing and damned. They seemed not to see him, those faces; they seemed like frames from a horror holo—like beckoning pleas that didn't know where to turn. Worst of all, they were coming and going in all directions. Of all things, that was the most frightening of all.

Because the flashing red lights clearly indicated where the radiation shelters were.

The full fury of the flare would be here within minutes. There was no way of telling how bad it was; but if it were anything typical, anyone not in one of the shelters within half an hour of its arrival—and probably less—would receive a lethal dose of radiation, while even a few minutes would put you at serious risk of future cancers.

Those minutes were ticking away while he stood there.

"*Everyone, listen up! Follow me! Follow me now!!*"

Zed headed for the nearest shelter entrance, shouting over the klaxons—

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and his own brain—pushing his way through disoriented bodies. As he went he grabbed arms, shoulders, napes of necks, waistbands—anything—and hurled them in the right direction. He kept yelling, until his voice was thick with phlegm. Both vocally and mentally. *Will somebody stop those idiotic klaxons!* "You! Come here, give me a hand. God damn it, help me! You too! Come on, let's go, let's go!" *Just keep grabbing people, keep pushing, keep shouting.*

Sure enough, the rush was diminishing. Bodies were vanishing, the hallways were thinning out. "Is this the way to go?" Some kid—barely looked fifteen, all fuzz-lipped and scared in the way you're really scared for the first time in your life. Zed pushed him in. "Yes, yes. Over here, this way. Come on, we haven't got any time!"

Finally, it seemed like hours but he knew it was only a couple of minutes, just enough time, barely enough; there was no one else, no voices, no frightened faces. He hurried the rest in, the ones who'd helped, patting them on the back, remembering their faces as best he could. Then, one last look and listen, he turned to the darkness and sealed the doors. Then he almost passed out from hyperventilating.

The flare wasn't a bad one, and passed in only a few hours. Still long enough to generate its share of complaints and moaning: "You'd think someone would do something about the inconvenience"; "I don't see why we have to huddle in here like rats"; "If I don't get out of here soon I'm going to . . ." "Don't they know I've got ice cream melting on my kitchen table?" The only thing missing were the usual moans about missing some big game or other. Zed remembered that flare they'd had during the Super Bowl: *that* was a chorus of howls he hoped never to live through again.

Uh, taking shelter during a storm isn't mandatory, you know. He knew better than to say it, though. Besides, strictly speaking, it wasn't true. But who was going to check every office, compartment, closet, and bathroom? If you wanted to die, that was *de facto* your own business.

It was *de jure* your right only if you wanted to battle Antarean monsters. The connection between the two was hideously obvious. Beam me out of here, Scotty; there's no intelligent life.

He poured himself a stiff drink when he got back to his compartment. Several, in fact. That loosened him up enough to laugh at what he knew would happen next. There would be hurried meetings of high officials; documents and memos would be written, detailing the need for more safety training. Maybe even a program would be put together before everyone forgot about it or convinced themselves that things hadn't really gone all that badly: after all, nobody had died, had they? And anyway, nothing can be made perfectly safe; space is inherently risky, we all know that, don't we? So what's the big fuss about?

Until someday, when something really bad did happen. A lot of people were probably going to die so that the living would wake up. Zed poured another drink and fell asleep with that cheery thought in his mind. He had a terrible nightmare: he dreamt nothing at all. Must be like what being dead is like, he decided when he awoke, depressed and hungover.

"No, no, *no*! Don't you see, that won't work!"

He smacked his hand to his head, which didn't help the migraine he felt coming on. Taking a deep breath and steeling himself against the pain, he explained, in a calmer voice, "Didn't anyone research this scene before programming it?" The blank faces answered his question. "OK then, let me let you in on a little secret. No way in hell are you going to rocket to Jupiter on chemical propulsion, scoop hydrogen out of its

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atmosphere, and escape a gravitational well of that size with that kind of impulse. Even if it is the only way to escape Alpha Centauri pirates, who, incidentally, couldn't pull off the same stunt themselves even if they could exist, which they couldn't because Alpha Centauri is a trinary star system without any terrestrial planets in stable orbits—a fact you would know if you'd checked the Deep Solar Orbital Baseline survey done twenty years ago."

Zed immediately wished he hadn't put quite so much sarcasm in his voice, but exhaustion and exasperation had taken their toll on his patience. Now he was forced to face hostile and embarrassed countenances, and figure out with what energy he had left how to obtain their cooperation. His conversation with Wu-McAuliffe encouraged him, but even that had to have its limits. He was becoming increasingly worried that he'd exceeded them, or was about to.

"Look," he added contritely, "I'm sorry. I didn't mean to snap at you all like that. I realize that this is very stressful for all of us." He paused to let them gauge the sincerity of his words (and wonder how sincere they were himself). "However, we've still got a script to program, and it has to meet all its expectations. And that means we're all going to have to hit the books. And our imaginations. And come up with something entertaining *and* realistic. OK?" He looked around his office at the dubious faces, and suppressed a sigh. "Right now though, I'd say we all need a break. A good two hours ought to do it. Do whatever you want with it: sleep, get drunk, stare at the stars, have an orgy—whatever you want, as long as it doesn't have anything to do with work. Then we'll get back together with our minds clear and see what we can put together. Everyone agreed? Good. See you later. Have a blast." He put on a weak smile.

Zed's idea of doing something that didn't have anything to do with work was to tease a loose thread that had gotten into his head recently. It had something to do with his boss. A familiarity he'd always sensed but paid no attention to; somehow now, however, it tugged at him with a hint of significance. It was right there, right off the tip of his nose. . . . he felt that if he could reach his tongue far enough, he could taste it.

When something bugged him like that, he knew there was nothing to do but let it have its way; resistance, as he seemed to remember hearing from somewhere, was futile. And somehow, that was connected too. Hell, it was all connected. If only he could figure out how.

Well, he knew where to begin. Personal data profiles were private beyond all but the best—i.e. worst—hackers, but if you put together enough queries and cross-checks and used your God-given imagination, you could start to weave things together. Of course, there being hundreds of things about anyone that you could think off the top of your head, that could be time-consuming, to say the least. Which was why he wasn't discouraged when the first couple of dozen attempts turned up nothing. He wasn't discouraged, but was even more tired and needing of relaxation if he were to be any good when they got back together.

It was hopeless. He sauntered over to Robbie Remmer's joint, a semi-seedy bar with just enough characters in it at any time to make it interesting without being too dangerous. He found an empty table, considered a few beers, then decided what the hell and opted for a glass of white wine. That got him some looks, but he was almost beyond caring.

They were skyjacks, greasers, and grunts of all kinds, with the occasional real tech assistant deciding to be one of the "guys" thrown in for variety. Zed leaned back in his seat and enjoyed the sight and the wine. He knew a lot of people who looked down a few astronomical units of nose at the men and

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women here. Class snobbery certainly hadn't been dismantled by the High Frontier, in case any fool thought it would have been—but he'd always had a higher opinion of them; a higher opinion, he suspected, than they had of themselves, in fact. He'd bet not a one of them wouldn't score better than average on any intelligence test devised by man or machine, and some would do surprisingly well. You didn't get here by being a complete idiot, that was for sure, despite what that solar flare suggested. It was only compared to the high(er) brows that they came off on the low end of the spectrum. And unfortunately, like those at the bottom everywhere, they took a paradoxical pride in being uncultured and uneducated. Which was why they'd performed so miserably during the flare.

It made him shake his head in despair. If only someone would take the time to teach them, to raise them to their full capacity. If only someone thought of them as thinking beings, instead of creatures. Ah, if only . . .

Which was what he was trying to do, now that he thought about it. Treat these "low-lifes" as if they had the brains he knew they had. Educate them. Raise their sights to the even higher heavens.

The wine was talking, he said to himself. But that wasn't really true, and he knew it. He'd taken the position with McAuliffe precisely—well, at least partly—because he believed in all those mellifluous sentiments. He didn't want merely to create—he wanted to teach.

He wrinkled his brow. Whether it was wine, or his maundering thoughts, something was triggering a connection somewhere. Again, it had to do with . . . with . . . damn! It just wouldn't come together. It was like a jigsaw puzzle, all jumbled up, challenging him to figure out where to begin putting it together. It was a taste, hanging out there.

Shaking it off again, he paid his tab and went out into the station's corridors, wandering them at random, observing small things, stopping to take in his surroundings, closing his eyes and feeling the steady hum of technology defying the elements, looking out of portholes and the vastness around them. There was something ineffably human in it, and yet common at the same time. He had the sense that everyone felt it, but had so long ago learned to take it for granted that they failed to appreciate it anymore.

He knew he wanted to recapture that.

His badge was chirping him. "We got some more ideas, if you're ready, boss," Eli Esu's voice answered his acknowledgment. Zed checked the time. How could two hours, and more, have passed out of his life so quickly? "Jesus, I'm sorry. Didn't realize it was so late. Be there in five minutes."

"Right, boss."

It was better this time. He wasn't sure whether a mag-sail of that size would do the job at Neptune's distance, but that was a detail that could be patched easily enough. And having the aliens use Alpha Centauri as a way station was plausible enough; they could figure out their original system later. He nodded approvingly; it still wasn't perfect, but this at least was on the right direction. Especially, he liked the touch about the fluorine breathing; there were some bio and other chemical challenges there, but that made the ETs deadly just to be in the same room in, unless you were *very* well protected: fluorine was nasty, nasty stuff.

"So they use UV lasers made with doped gallium arsenide," he agreed. "Vicious. How are our heroes going get away without a hulled ship?"

Faces looked at each other. Finally Esu piped up. "Well, we're kind of thinking about converting some of the human's oxygen supply to solid ozone and using it as an ablative shield. But we want to talk with our consultants about that a little more; the decomposition reaction might be more violent than the laser. Be-

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sides, what if they don't have enough oxygen?"

"Still, it has promise. Good work." Zed thought moment. "Maybe they could refill their tanks directly out of Neptune's clouds. There's some free oxygen there, as well as water."

"Uh-huh. Sure, we'll check into that. Anything else?"

"Just keeping posting me on the hour. We've got only two more days 'till the big girl's deadline." *And I think she'd be just as quick to fire a bunch of writers as a director*, he added mentally, hoping the others got the same message. This time his smile was broad, however. "Thanks. You're all doing a terrific job."

They left with equally wide grins on their faces.

Damn it, maybe he was actually accomplishing something.

He heard about the shuttle accident later. One of the docking rings had failed: that wouldn't have been a disaster in itself, or even a serious problem, if someone hadn't disabled the warning system and if others hadn't failed to notice that both backups were faulty from lack of maintenance. Even still, it was for lack of a thorough suit check that a fatal case of bends claimed the woman's life. Enough ruptured blood vessels put a body beyond even what the best modern surgery and artificial organs could do.

It all happened in less than a minute.

This time there would be a real investigation; rear ends would be canned, a program put into place, safety violations more seriously punished. Zed went back to Robbie's place and cried with the rest of them, into beer. Yet even in his tears, the irony was not lost on him: here he was, crafting a virtual reality of humans living and dying in space, and the real world of blood and flesh and loved ones had come crashing through. And he hadn't even known the victim. He didn't have to. None of them did: that's what death did to you.

And yet, in an even greater irony, it was the trigger. Now he knew.

He still checked it out, of course. This time it was easy, now that he knew what he was looking for. When the confirmation splayed itself across his desk, he nodded knowingly, with a smile of a man who'd solved a mystery that had been plaguing him for far too long.

Then he marched straight to his boss's office.

She confirmed the truth without hesitancy. "Yes, she is a distant relation of mine." She narrowed her eyes at him. "Now you understand, don't you?"

"I've read the history. Christa McAuliffe died in the Challenger explosion, almost a hundred years ago. She died because the NASA bureaucracy at the time had gotten lax about safety; they were so confident in their shuttles that sending a schoolteacher up in one of them sounded like the perfect public relations ploy."

"And the results almost destroyed the manned space program," Wu-McAuliffe continued for him. "It was years before they sent any more shuttles up, and decades before they started sending 'ordinary' people into space again. We got lucky the next time, though, fortunately." She shook her head. "People get complacent. They take things for granted—get lackadaisical. It's not that they don't care, but . . ." She shrugged at human nature. "Out here, that can still kill you, real fast—as we've just seen." She switched subjects on him. "By the way, how are those scripts coming? I still expect them done on time."

It took a moment for Zed to readjust his thinking. "I'm becoming satisfied. The science in them is a lot more realistic, at least. With a little more polishing I can . . ."

"Never mind that," he was rudely cut off. "That's not your job anymore. You're fired."

"I—I'm what?!"

She steepled her fingers again and grinned savagely. "A new position has

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opened up. We've decided to create an Educational Division. Interested in applying for the job?"

Zed wondered if he were dreaming—or worse, hallucinating. He sat down, realized his mouth was agape, and closed it. "B-but the scripts . . ."

"Someone else can take care of that. You've put them on the right course, and believe me, I'll make sure they stay there. But we desperately need a top mind to work on the training and educational scripts that everyone's going to be demanding as soon as the investigation into that accident is finished. Before, even. From what I've seen and heard, I can't think of anyone better to start producing those than you. So I'll ask again. Do you want the job?"

Zed's head was spinning. "My God, I don't know what to say."

"You just said yes." Wu-McAuliffe stoop up and offered a hand. "Welcome aboard, Dr. Jones. I know you'll be a valuable member of our team."

Zed found himself accepting the hand on automatic. No, not automatic: he really did want the job. Hell, now that he thought about it, he wanted it more than any job he'd ever had. There'd always been that part of him that wanted to teach. Now, finally, that part would come fully to life.

Then he thought of it. "Christa McAuliffe was a teacher too, wasn't she?"

"She was the best teacher I ever had," Wu-McAuliffe admitted. "I hope someday to take the place she had." She saw Zed didn't understand. "Dr. Jones—Zed—let's face it: our job is easy. We tell other people what to do, and it's their problem to figure out how to do it right. Our only advantage is that we get to learn by watching them. One day, when we're ready, we'll be doing the same thing." She looked thoughtful. "I remember a science fiction story I read—I mean read, not a VR script—which showed a man working his way through the educational bureaucracy. He started as the superintendent of the entire school system, and then, through hard work and perseverance, eventually worked his way up through principal of one school, then finally they allowed him to actually teach in a classroom." She stopped and let Zed mull the concept over. "In a lot of ways, I think of us as doing the same thing. But we've got a lot to learn first. Don't you think?"

"I think . . . I think," Zed said, "that I've learned a lot just sitting here."

"I also remember another story about space being a friendly environment; in fact, I think it used exactly those words. Well, it isn't, not in one way. But in another: anything that keeps us on our toes and makes us keep thinking and rethinking, and learning constantly—that's the only environment human beings *can* ultimately survive in."

She glanced at her time display. "I'd love to sit and philosophize with you further, but both of us have a lot of work to do. I've got to start on the organization structure of our new division. And you—the first thing you've got to do is move into your new office. It's the one right next door to mine." She shook his hand again. "Thanks again, Zed. I look forward to working with you."

Zed stepped out of the office, his thoughts still in a blur, though his spirit felt as if it were on the right track for the first time in his life. Still, he stopped at a porthole, and gazed out, this time and the stars, unfiltered by either sun or earth or moonlight. He recalled a conversation from a long time ago, with a professor whose name he had long forgotten. Even the exact words failed him now. All he could remember was that it was the one who predicted his life would be lost.

He suddenly wished he could meet that professor now—if for no other reason, than to show him what amazing things you could find if you looked long enough.

He laughed, and continued on his way. □

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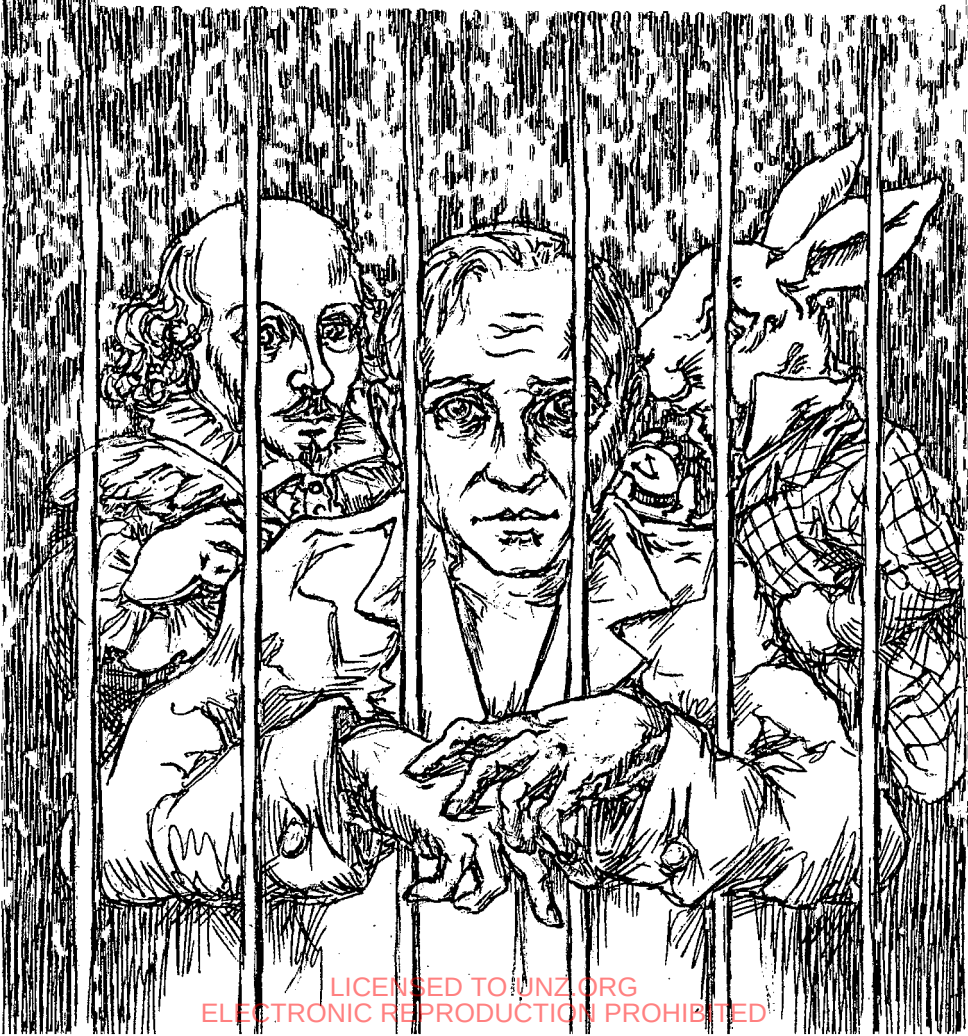
James Van Pelt

NOR A LENDER BE

Some old saws have kinds of truth in them that no one suspected. . . .

Illustration by Darryl Elliott



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On a park bench near the swings, the old man in an overcoat eyes the children. He's positioned himself carefully away from the parents who are talking amiably on a set of benches on the other side of the playground equipment. Near him, a pair of boys dressed in matching blue jumpers take turns going down the slide. The old man studies them for a while. They're maybe five and four, he decides, very sweet; they smile often; the same shade of blonde hair curls out from beneath their caps.

On the teeter-totters, a handful of older kids, around nine or ten years old, rise then fall in rhythm. They laugh in unison at some joke. Beyond them on the grass, a couple of teens throw a football back and forth. The old man sighs and looks at his hands. Liver spots mar the knuckles and make indecipherable patterns on their backs. He imagines things crawling under his skin, moving beneath the loose parchment of his flesh. He resists the urge to scratch his fingers. When he raises his left hand from his leg, it trembles slightly.

Underneath the slide, a little girl sits against a support pole, drawing patterns in the gravel. She's maybe eight, the old man guesses. Her blonde hair matches the boys going up the ladder. Her lips are thin and serious. She concentrates on what she's drawing, erasing a part of it and starting again. When she finally looks up, as if sensing she is being watched, her eyes are dark brown.

"Hi," she says, not lifting her finger from the spot on her drawing.

The old man glances at the parents on the other side. They're facing each other, chatting. Nobody seems to notice him or the child. He gestures to her—a come closer wave.

"Hey," he says. "Hey, little girl. Do you want to know a secret?"

She looks at her work for a moment, makes a final line in the gravel, then gets up, brushes the back of her dress and says, "Do you know one?"

"Sure," he says. "A good one. Come a little closer so I can tell you." He keeps his hands on his legs so she won't see the trembling. The trembling might frighten her. If she knew about the things under his skin, it might frighten her. If she knew what swam behind his eyes, it would drive her off.

The two observers, a black-haired woman in a grey pantsuit, and a man, sporting old-fashioned glasses, jeans and neatly pressed sport shirt had come into class at the beginning, taken seats in the rear, then not moved other than to whisper quietly to each other during William's lesson on *Hamlet*.

William paid them little attention. Visitors came to his class regularly: parents who'd just enrolled their kids, still suspicious of a live teacher instead of a computer DeskTop unit; media people with tiny cameras who'd film for their programs ("Retro-Teaching Survives in Colorado" was the title of a piece a week earlier); board of education members, each with their own agenda, etc. They'd make notes about the semi-circular desk arrangement, how much William talked, how often students responded. The minute details seemed to fascinate them. Sometimes old folk came in to wallow in nostalgia, to remember when all schools used to be like this.

William concentrated on the class of fifteen students; they were playing a quote game.

"So," said William, "If I were your boyfriend and you wanted to dump me, what might you say?"

Sheila, a sixteen-year-old with a splash of freckles across her cheeks and nose, nervously raised her hand. "My Lord, I have remembrances of yours that I have longed to deliver?" She paused, pantomimed handing him something, then smiled when William took it. Her fingertips brushed his palms. She said, "I'd tell you that if I returned your ring or something."

William nodded again, leaning toward

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her. "Yes, Sheila. Exactly. But what if I denied it hurt me? What if I were a creep and said to you, 'No, not I. I never gave you ought'?" He said it gruffly, brusquely as if he really was irritated at her, as if he despised the idea of her.

"My honored Lord," she said, flushing. "You know right well you did. And with them words of so sweet breath composed as made the things more rich." She sighed. "I love that part."

William wandered around the room. The students watched him; he could feel their eyes—their attention—centered on him. It was always this way: the interaction, the game with the things he loved and the class, like opening a great oak door between them and the material, and he remembered again the first time he'd really understood Hamlet, facing the ghost on the stage, talking into the darkness, "King, Father, royal Dane. Oh, answer me! Let me not burst in ignorance."

William shivered. Literature struck him so immediately. He could feel it in the air, shimmering out of the texts on their desks. He said, "What if I were angry with someone and wanted to call him a name? Can any of you give me an insult?"

Jason, a skinny, pale boy said, "Bloody, bawdy villain! Remorseless, treacherous, lecherous, kindless villain!"

"Ouch," said William, grinning, as he stuck an imaginary dagger in his chest. Several students laughed.

Just as strong in room as the presence of Shakespeare were the kids, all of them awake for a moment in this play. William felt like a friendly conductor, punching their tickets on the Hamlet express. They'd boarded as they always did—a bit full of the world, distracted and fragmented, but the rocking of the iambic rails had lulled them into receptiveness. William had played Polonius for them at the beginning of class. He'd said, "I do know, when the blood burns, how prodigal the soul lends the tongue vows."

They'd been caught. By the time he'd gone back to "Neither a borrower nor a lender be," they'd dropped every concern they'd brought to class. It was just them and Shakespeare and William playing three-cornered catch. He closed his eyes to feel it washing over him, and he almost forgot for a moment what they had been doing until Rupert, a dark-eyed boy, cleared his throat before speaking. "What if I said that you were an old man whose face was wrinkled; your eyes purged thick amber and plumtree gum, and that you have a plentiful lack of wit?"

"I'd say, 'Though this be madness, yet there is method in it.'"

Red-haired Tracy said, "Do you think Hamlet was mad?"

Dirk, who sat behind her tapped her on the shoulder. "'I am but mad north-north-west. When the wind is southerly, I know a hawk from a handsaw.' Hamlet knew what he was doing."

Five hands shot up.

"In quotes only," said William.

A bell rang, ending class, and several students groaned in disappointment. They gathered books and headed to the door.

"Good night, sweet prince," said Rupert as he left. Jason prodded him and said, "Ah, ha. I knew it. Women delight you not."

Rupert's voice drifted into the classroom from the hall, "What a piece of work is a man. How noble in reason, how infinite in faculties . . ."

William chuckled and turned to his desk.

"How impressive," said the woman in the pantsuit. William jumped; he'd forgotten about his visitors. The woman rose and her companion followed her, standing slightly behind her to one side. "Victoria Baseman," she said, extending a hand. "Of the Reinhart Group. This is my intern, Isaac. We'd like to talk to you about what you're doing here." She looked around the room. Student artwork covered most of the walls: painstakingly hand-drawn renditions of

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The Globe Theater, examples of Elizabethan dress, and scenes from *Hamlet*. "The students appear to enjoy learning." Isaac, who might have been twenty and easily ten years Victoria's junior, took notes.

"That was . . . amazing. I was moved," said Isaac. Victoria shot him an annoyed frown.

William pushed the student's papers into a pile, trying to appear calm. The Reinhart Group had swallowed Disney a decade ago, and had made massive strides into education in the last few years. Half the corporation schools in the country relied on Reinhart funding in one way or another, and they were one of the few companies who made money in the field since the privatization of schools thirty years earlier. "They're a good class. It's easier when they're motivated."

The woman consulted a data reader in her hand. "Looks like *all* your classes are motivated. Best test scores in the country."

"It's the school," said William. "The curriculum works."

Victoria snorted derisively. "False modesty. You've changed schools three times with a different curriculum each time. Your students excel when you're there. They're average when you're not. It's not the curriculum; it's you."

"I just teach them one day at the time. I've been blessed with good kids."

"The Reinhart Group thinks it's more than that. We've done extensive studies of student behavior—your students—and we've made interesting conclusions. Because of them, we'd like to make you a proposition." She sat on the edge of his desk.

"I'm happy here," said William. "I like the area." He pushed essays into his briefcase. "They pay me well."

Victoria put her data reader into her jacket. "Fifty years ago, you wouldn't have been so lucky." She turned to Isaac. "Fifty years ago teachers weren't paid by their successes. Good teachers, bad teachers, it didn't matter. They were paid the same."

"That seems silly," Isaac offered quietly, "Doesn't it? Why would anyone work hard?"

"Surprisingly, many of them did anyway. Teaching's more of an avocation than a vocation, wouldn't you say, William?"

William nodded. He wondered what she was leading to.

She continued, "But the schools weren't very good, just the same. When public schools collapsed and the corporations took over, good teachers were bid for. Bad teachers got better or quit. Generally education improved, and education became big business."

"Yes," offered William. "But there are still failings—whole groups of kids who are under-served."

"Of course," Victoria said. "The corporate model has problems too. Applying management principles to classrooms hasn't made them all that much better, at least not as good as they need to be, despite the different approaches."

Isaac said, "You mean like individualized, home study."

"Yes, everything done at home through computers. No classrooms. No group contact. Interesting experiment," said Victoria. "An approach the Reinhart Group invests heavily in, but getting rid of the schools as structures hasn't done it. No, the problem is that every approach emphasizes curriculum."

Isaac looked puzzled. "Naturally. Curriculum and technique can be duplicated. It can be marketed. What else is there?"

"The teacher," said William.

Victoria nodded her approval. "Yes, the teacher. So we went big into teacher recruitment and training. That's why Reinhart is *the* major player in education. But it's time to make the next jump. It's time to get rid of the corporate model that relies on thinking of curriculum as product. The product model is dead."

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Isaac said, "But what can replace it?"

"Yes, what?" said William.

"The pro-sports model is our new direction."

William sat on the edge of his desk. He'd read of something along these lines in the latest journals.

He said, "It's elitist, isn't it? Sell the superstar teacher to the high bidders? I'm not interested in teaching to a half-dozen rich kids."

"Of course not," she said smoothly. "We know you've turned down similar offers. No, we're ready to take the next, logical step. The pro-sport model of education is like a pro-sports team. We need a franchise player, though, a Babe Ruth. Someone who is so much obviously better that success rests on that person's shoulder."

"How's that different? There's only one of me."

Victoria smiled, and William realized she'd led him to this question. He admired the technique; it seemed so Socratic.

"That's our new direction. We want you to be the franchise player, but not like those pro stars. You are a superstar teacher, the maestro of the blackboard. No one is any better. You're the best. But there's no profit in selling you *individually*. We can't make enough. We don't want to buy you; we want to buy your style. Then we can franchise it."

Isaac said, "And we're willing to pay you really, really well."

"Do you know the story of Alice?" the old man asks. He leans close so his voice won't carry.

The little girl scrunches her hands in her lap. She doesn't appear uncomfortable, just interested in how her skirt wrinkles when she plays with it. "I don't know an Alice," she says.

The old man looks at the parents across the play area. They're still animated in discussion, not paying attention to anything beyond their talk. He doesn't see any police officers. A breeze rustles the willow behind them. He says, "Alice is a little girl, just about your age, and her story begins with a rabbit. Do you know what a rabbit is?"

"I've been to a zoo," she says. "I saw a cat and a porcupine there, too."

"Of course you have," says the old man. "I knew you were a bright little girl."

"So, what about Alice?" she says.

"And inquisitive, too. Oh, you're a bright one for sure." He settles back in the bench; he touches her shoulder gently. "Well, the rabbit is late to begin with, and he has a pocket watch. Why do you think he might have a pocket watch?"

"The rabbit has pockets?" The little girl covers her mouth and giggles at the idea.

"He's a special rabbit. Do you want to know all about him?"

"Oh, yes," she says. "My dad has a pocket watch, too. It's on a big chain, but it's a lot more than a watch. He says it's his little assistant, and it's really expensive. He downloads it all the time, and I can't play with it. Tell me why the rabbit has one."

The old man checks the parents once again, slides toward her so their hips nearly touch and begins the story. Within a minute, he's forgotten about the crawling under his skin, the extra presence behind his eyes—he's into the story, and he's into her being into the story.

What sold William was Victoria's picture of the product: "Imagine your successes happening with students all across the globe. More and more kids in love with education, with learning, helped there by our simulacrums of you."

By this time they were sitting in the bar down the street from the school. Victoria had bought drinks for them all, and they'd talked about education for a couple of hours. The lights hung low and dim over the tables. Victoria's eyes glistened with interest, and her face glowed. After a while, William found

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her to be totally sympathetic to his views. "Teaching's about reaching," he'd said. "You have to touch the student with the material and your enthusiasm, or nothing happens."

She'd nodded encouragingly and ordered another round. Isaac took notes and moved empty glasses out of their way. "So how do you do it?" Isaac asked. "Are you a stimulus-response man? Do you teach 'whole language'? Or are you into one of the more traditional, back-to-basics modes?"

William leaned back in his chair and crossed his hands on his stomach. Over the years he'd developed a slight paunch, but it didn't worry him; it made him feel comfortable, like Pooh Bear or Bilbo Baggins. It was the way he imagined a forty-year-old confirmed bachelor should look. He said, "When I first started teaching, I played around with lots of theory, but I don't think much about it anymore. I guess I'd have to say I'm pretty unconscious about technique. The kids are there; the material is there. I teach."

Victoria said, "Like Mickey Mantle."

"'Scuse me?" said William. He nearly missed the table with his elbow when he straightened up, and he realized he'd drunk a bit too much.

"Mickey Mantle was a great player. Maybe one of the best hitters ever but not much of an intellect. One day he was giving a batting demonstration for a bunch of little leaguers, and he was trying to explain to them about foot placement and how to hold the hands and where the elbows should go, and the longer he talked the more tongue-tied he became and the more frustrated. Finally he couldn't stand it any more and said to the bunch of little kids, 'Ah, hell. Just hit like this,' and he tossed a ball into the air and belted it over the fence. He couldn't explain it, but he could do it."

"Maybe I'll be no good for you, then," said William. His face sagged with sadness and the bar darkened. He'd begun to think of Victoria and Isaac as friends. They liked education. They understood the passion of teaching. They liked him, and he wasn't going to be able to tell them how he did it. The money didn't matter. Victoria had painted a vision of thousands of students in love with literature. He imagined them lining up for play tickets, a new audience for Shakespeare and the rest, and now they were turning away all because he couldn't tell these nice people how he taught. "I don't have a method," he said, looking into the depths of his drink.

Victoria put a hand on his wrist. Her fingers felt cool and delightful, and William began to think of her like Shakespeare's dark-haired mystery woman who was a part of the sonnets. "You don't have to. That's the beauty. We can study your teaching while you're in the classroom. We can capture it, and can it, and reproduce it. All you need to do is what you've always done, which is teach. We're not buying a technique. You could teach a technique, but no one could do what you do. What we want is for you to sell us your style."

A half-hour later, Isaac pulled a sheaf of contracts from his briefcase, and William signed them all.

Victoria said, "You're a rich man, William. You'll never have to work again, but you'll be reaching thousands. What a legacy. What a legacy."

Their knees touched under the table. William was sure that it was an accident, but he was thrilled just the same.

He didn't remember the ride home.

A week later, the technicians were waiting for William when he entered his classroom. They were white-suited and entirely businesslike. He could barely tell them apart as they placed dozens of silver dollar-sized disks on the walls and ceiling.

"They're transceivers, William." Victoria said. She wore white like the rest, and her black hair spilled over her shoulders. "We'll be recording everything you and the students do while our comput-

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ers build a model of your responses to student cues. Our programmers tell me that this part of the process will last three months."

William scanned the room. The disks matched the wall's colors, and he could tell that they'd be easy to overlook.

"That doesn't seem like it'd give you enough, though. A bunch of vid of a teacher won't give you everything the teacher does. So much of it's internal." He was only half paying attention. Today he'd be starting with a new group of students, and his lesson plans filled his mind. Beginnings were so much fun, he thought. Starting them off right was part of the secret.

Victoria half sat on the edge of his desk. William liked the pose; it made her look long and sultry. It was distracting. He imagined writing her a sonnet.

"So how are we going to get more?" she said.

William recognized the strategy. She'd used it earlier on him. "You're being Socratic again."

She smiled.

He said, "All right, do the disks do more than vid?"

"Good question. Yes, they do. What else do you think we need to capture your style?"

He turned the problem over for a bit before saying thoughtfully, "Teaching is mostly responding to the audience. What works great one time might crash and burn the next. So you've got to get inside my head, somehow. You need to see the students the way I see them, or it will be useless."

"You come to the point readily. So how are we going to get inside you?"

Something he'd signed on one of the contracts surfaced in his memory; most of the evening was lost to him now in a blur of pleasant drink and conversation. "A new technique, you said, I think. Some way to, umm, more closely monitor the environment."

"Your environment, to be exact," said Victoria. "We need to monitor you, so we've designed some very special nanotech to do the job. You'll need to be injected, of course, and it will be a few days before we have everything adjusted, but by this time next week, we will be getting a complete picture of the students and the classroom as you experience them. Not just visuals, but touch, smell, taste—all of it. All the subtle cues you use to teach from and how you respond to them."

Behind her, one of the technicians was preparing a hypodermic. She drew what looked to be a couple of cc's from a small bottle of cloudy, white liquid.

Victoria said, "It's really no different from what the doctor might give you to clear cholesterol from your system, or to hunt down cancer cells. Only these will attach along your nerve pathways. Totally painless, naturally. You won't even know they're there, but they'll broadcast to the transceivers while the computers build the model of your behavior. In three months, we'll have everything we need."

"That's sophisticated stuff." William bared his upper arm to receive the shot.

"It's proprietary. We'll have to keep you under surveillance outside of the school. Industrial espionage, you know. Afterwards, we'll neutralize it and you'll be free of our interference in your life. It's a small price to pay for the price we're paying you." Victoria patted him on the arm. "There. All done now. We'll clear out before your students arrive."

The technician said, "You might run a slight fever for twenty-four hours. The mechanisms will be duplicating and some people react to that."

William's arm felt warm at the injection site. It spread up his arm into his shoulder. Not unpleasant, but a little creepy, he decided. He felt as if he were being invaded, not like nanotech in the doctor's office, which didn't seem any different from medicine, but like his system was filling with spies. He decided he didn't like the idea of tiny transmitters seeing what he saw. It made his eyes

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itch to think of it, but he stayed calm. It's a silly reaction, he thought. Nothing will go wrong.

The police officer approaches the old man and his young companion on the bench while the old man recites the Lobster Quadrille for the third time. "Will you, won't you, will you, won't you, will you join the dance?" he says to the girl. She looks up at him and smiles.

"I wish I could join the dance," she says.

The old man glances at the officer, who stands in front of them, his arms crossed at the chest.

The old man whispers to the girl, "Remember, the further off from England, the nearer itis to France."

She recites back to him, "What matters it how far we go? There is another shore, you know, upon the other side." She claps her hands and laughs.

"Good girl," he says.

The officer clears his throat. "You're doing it again, William, aren't you?"

"What?" says the old man. "I'm just being myself."

"That's the crime," says the officer. "You're not going to make me cuff you this time, are you?"

William closes his eyes. He believes he can feel the nanotech moving around behind them, quietly capturing everything he does, still broadcasting the essence of himself to unseen transceivers. They're under his skin. They're coating his heart. "No," he says. "Not this time."

He stands and says to the little girl, "The book is called *Alice in Wonderland*. You can look it up if you want to know the rest of it. There are other books there too, like Shakespeare. Books for when you're a big girl. Make sure you read *Hamlet* when you're older. You'll like it."

"Thanks, mister," she says. "I will. Thanks a lot."

Within a week, William had nearly forgotten about the disks. He almost never looked for them. The students didn't mention them. He was into the ebb and flow of the class. As always, the kids started off as ciphers, completely unknown and blank. Some had gone through dozens of educational strategies before arriving in his room. All had been on a waiting list for at least a year. They won their spot by lottery. He was highly paid. His school marketed him and the other teachers on the staff through international advertising; like all other schools, they competed for the students, offering a program of study and a tradition of results.

William didn't care. He'd teach in a barn. He'd teach at a bus stop. Every concern dissolved in the face of students and the material. He was in his medium. He thought about sports superstars; did they play for the money? How could they? At the top of the sport, with no human peer, they had to play for love. That old basketball legend, Michael Jordan, going for the hoop, flew for the love of the game. William had heard stories that late at night Jordan used to strap on old tennies and head for the neighborhood civic center in Chicago to play pick-up ball. Some of the press knew it, but no one ever put it in the paper. At two in the morning he'd be setting picks and flicking passes to street players who came in to run hoops instead of hanging with the gangs. Jordan just loved to play.

So William ignored the disks. He moved from desk to desk. He set up small group discussions. A tap on the shoulder here, a well-timed smile there, and always the shades of literati that he brought back to life for the students: Shakespeare, Homer, Dickinson, Brontë, Carroll, and Twain.

The only disturbance in the beauty of the lessons happened in the quiet times in class. He'd be sitting at his desk, watching the students read, and he'd feel a shift under his skin, a subtle sliding like the slipping of a sheet of paper

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from the middle of a stack. Or a sudden irritation behind his eyes. He imagined nanotechs with legs, running from one nerve ending to the next, leaving tiny footprints on the back of his retina. Even at home, without the disks, he felt observed. They were with him, and they never went away.

William took hot showers. He scratched his skin sometimes until it was raw, then he'd scold himself for the silliness of it. At the microscopic level the nanotech operated in, he could never really feel them. They weren't doing anything. Still, he went through several bottles of calamine. In the quiet times of class, he'd sometimes feel like a fly in a web, and every disk held the end of one string. He squirmed slowly in the middle, connected by the radiant lines of the disks.

At the end of three months, Victoria and Isaac sat in the back of his room again. Except for technicians who came in occasionally to reset the disks, William had seen nothing of the Reinhart Group.

Victoria looked better than ever. She'd crossed her legs at the ankles, and William was keenly aware of her posture, the turn of her hand on the table, the tilt of her head, the half-smile he imagined lifting the corners of her mouth when they met eyes.

"Bravo," she said, after he'd dismissed class and the last student had left. "A truly outstanding performance of the teacherly arts."

William blushed. "They were a good group."

Isaac said, "You have no idea."

Something in the way his comment sounded caught his attention. "What do you mean by that?"

Isaac cleared his throat nervously.

"Oh, it won't matter now," said Victoria. "Go ahead and tell him. It was partly your concept anyway."

Isaac held his clipboard to his chest. "We would have told you earlier, but we were afraid it would disturb your style. Maybe it wouldn't. You did fine with all the scrutiny anyway, but this wasn't your normal batch of students."

"Not at all," said Victoria. William glanced between the two of them, confused.

Isaac continued, "We hand-picked this class for a wide range of learning styles. Several of them were classic reluctant learners. A couple were ultra-high achievers. We tried to mix them up as much as possible. We needed your reaction to all kinds of students, so this way we guaranteed it."

Victoria signaled to someone outside the door, and a group of technicians swarmed in and began removing the disks from the walls and ceiling. She said, "The students were nanotech-primed also, the way you were. We recorded their perceptions of the class too. It truly was remarkable. Do you know that you respond to bored or drifting students *before* they know they're bored? I was stunned. It has been a phenomenal display."

"Oh, yes. About that. When will you . . . you know . . . remove them?" William resisted the urge to scratch his forearm. Even thinking about the germ-sized observers made him itchy.

"Right now, naturally." Victoria tilted her head to one of the techs, who immediately began preparing a syringe. "They would break down on their own in the next few weeks, but this will make sure that none of our competitors get hold of them."

"I wouldn't go to any of them." William drew himself up and straightened his tie. "It would be dishonorable."

Victoria stepped aside so the tech could get to William's arm.

"We're not worried about *you*, William. But our competition might not be so pure in spirit. You'd probably wake up in an alley with a tremendous bump on your head and a bruise on some vein from a sloppy shop-doc who just wanted your blood."

This shot hurt going in, but there was

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no warmth in his arm or shoulder like the first time.

The last tech cleared the room in a few minutes, and only Victoria, Isaac and William remained. Victoria shook his hand.

"Don't spend all your earnings in the same place, William. I doubt you could. It's been a pleasure working with you." She waved to Isaac, and he rose to leave.

William's throat suddenly felt dry, and he swallowed a couple of times. "You mean, that's it? We're all done?"

Victoria turned back to him. "That's it. But your contribution has been invaluable." She laughed. "Don't tell the accountants that I said that."

"I thought . . ." William cleared his throat. "I thought we could talk over the project some more. Maybe during dinner." He coughed. "Or something," he finished lamely.

"Oh, William," she said. In the pause that followed, William felt like he was abruptly unanchored in his own room. The shot coursed through his veins, and it seemed he could feel the company's nanotechs being neutralized within his blood: a million deaths happening inside him at once. He realized he'd made a terrible mistake.

"You really are precious," she said.

The first time he wasn't arrested.

William had prepared for his next class as he always had, rereading, writing new notes, preparing new plans. He was excited about a vid that he'd shot a month earlier in the recreated Globe theater in South Hampton. The New King's Men had played *Comedy of Errors*, *Henry the Fifth*, *As You Like It*, *The Winter's Tale* and *Hamlet*. But as he bustled about his room, putting up posters (beautiful, brand-new art prints that his Reinhart money paid for), rearranging desks and rehearsing his introductory lecture for the next day, he felt distracted. He'd stop to itch the top of his hand or to rub his eyes occasionally. Even though a check-up the day after the cleansing injection confirmed it, he imagined that not all the nanotechs were gone. It was a crawly sensation, alien-like and disturbing.

As he reached behind his ear to rub a bothersome spot, an official-looking man in a gray suit knocked on his open door. After a brief introduction, mostly to assure the man that William was who was named in the papers he carried, the man served William with an injunction. Most of the multi-sheeted document was legal gobbledygook, but the essential part was clear: "Because of considerable financial and competitive risk, and whereas The Reinhart Group did in good faith purchase the style, mannerisms, content and appearance of the aforementioned party, he shall be forever forbidden from using the same said style, mannerisms, content or appearance."

"Essentially," the gray-suited man said, "you are no longer allowed to teach."

"They can't do that," said William, sputtering.

The next day, however, he found that they could. The school's administration called his students and rescheduled them with other teachers. His classroom was given to someone else and his posters returned to him along with a note asking for his resignation. The principal, a woman of indeterminate age and colorless hair, was very apologetic. "It's a copyright issue," she explained sympathetically. "They own the copyright to your style, and if we allowed you to teach, we'd be fined or face possible criminal charges." She offered him a handkerchief to wipe his eyes. "It's all very clear in your contract. You read the contract, didn't you?"

William shook his head.

"Oh, that's too bad. Well, you have plenty of money. You'll never need to teach again. You can enjoy your retirement. Travel. Read. Things could be much worse." She offered her hand, and numbly William shook it.

"They can't do this," he said again. His

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voice rose. "I'll take them to court. You can't confiscate a person's style!"

It took two years, and all the money that Reinhart had paid him, but he found out once again that they could.

Sitting in a book-lined office, William's lawyer, a scruffy-looking man who appeared perpetually unshaven but who was an old veteran of copyright law battles, and the absolute best man in the business, explained it to William their first conference. "The precedent is long established, but the most famous example is The Lone Ranger."

William said, "I'm not familiar with him." None of the books on the office shelves were literary. All were legal titles. Earlier when he'd tried to take one down, he'd found that they were merely decorative. The lawyer's computer stored the centuries of copyright law, rulings and precedents that the case would be argued from.

The lawyer said, "In the middle of the last century there was a television show called *The Lone Ranger*. When it went off the air, the actor who played the lead character couldn't find steady work, and he began doing promotional gigs as the Lone Ranger. He'd wear the costume and show up at the opening of used car lots and shopping centers. The studio successfully prevented him from appearing in costume because they owned the character, they argued, not the actor." The lawyer stroked the stubble on his chin. "It's a sad case, really. I think about that guy sometimes, these old Lone Ranger costumes hanging in his closet, and instead of being a hero like he was in the show's heyday, he's just a broken-down has-been who couldn't even pick up a few bucks for appearing at the ribbon-cutting ceremony for a fast-food place."

"That's bleak," said William.

Surprisingly, at the trial, Isaac offered to testify in his behalf. When it became clear that William could not beat the contract on its own merits, the lawyer tried to argue that William was drunk when he signed it. Isaac corroborated the drinking, but Victoria testified that William drank very little. On the stand she appeared imperious, unfriendly and very believable. The day after Isaac's day in court, he quit Reinhart and joined William's defense.

"I sat in your class that day and learned to love Shakespeare," said Isaac in way of explanation.

"But your job, Isaac," said William. "You didn't need to do that."

Isaac looked thoughtful, then furrowed his brow in concentration as he recalled, "Whither wilt thou lead me? Speak. I'll go no further."

Despite himself, William smiled. "Mark me."

"I will."

William said, "My next line is 'My hour is almost come when I to sulphurous and tormenting flames must render up myself.' I hope it doesn't come to that."

"Alas," said Isaac. "Poor ghost."

But it did come to that.

They arrested William the first time for teaching *Through the Looking Glass* under an assumed name at a small, family school in Mississippi. He had no money for the fine and served ninety days instead. Reinhart lawyers successfully argued that William should be isolated from other prisoners.

A year-and-a-half later, they caught him guest-lecturing on sonnet structure in a friend's classroom on the east coast. Ninety days again and a restraining order requiring him to stay one hundred feet from school-aged children. William learned that Isaac had formed a small lobbying group and was trying to change the copyright laws.

A third violation earned him a monitoring ankle bracelet. A sympathetic former student removed it, which was supposed to be impossible, and the student wore it for two months while William taught night classes in Shakespeare

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through a city-run continuing education program. Three violations put William into the scofflaw category, and he served four years.

By the time he was sixty-four, William had spent more than half of the previous twenty years in jail, always in isolation. Teaching kids in the park had become his favorite technique. Cops knew who he was, and he'd developed a kind of infamy with them. Most of the time they chased him off. Occasionally someone new on the force or a grumpy veteran would haul him in, book him and hold him overnight. Victoria ascended to the Reinhart presidency and seemed to have long forgotten her project from years past, but the meticulous wheels of the company's legal division ground exceedingly fine and continued to prosecute him whenever he was arrested.

He'd sold his books long ago, and he couldn't afford net charges for computer access, so his reading was limited to the public library. Not that it mattered. Most of the works he loved, he'd memorized.

The only result of Isaac's years of work on William's behalf was finally a suspension of the isolation order in jail as cruel and unusual punishment, but the problems with the law never stopped.

So, there is no surprise in him when he stands and says to the little girl, "The book is called *Alice in Wonderland*. You can look it up if you want to know the rest of it. There are other books there too, like Shakespeare. Books for when you're a big girl. Make sure you read *Hamlet* when you're older. You'll like it."

"Thanks, mister," she says. "I will. Thanks a lot."

The script of what is said to him at the police station seems as familiar to William as any play. He knows his part within it.

He pulls his overcoat close to him as they lead him to his cell. Modern as the prison is, with its soft white walls and acoustic ceiling, it makes him cold, and when he's cold, the ghostly writhing of long-gone nanotech bothers him most.

The officer is curt, businesslike. "We have to double you up with someone tonight. A delusional kid. Shouldn't bother you." He opened the cell door. A boy, no more than twenty, sits on one of the fold-down beds, his back to the wall, legs drawn up, a shock of black hair hiding his eyes. He doesn't look when William takes his place on the other bed. The cell is narrow; William's knees nearly touch the gray blanket on the young man's mattress.

Even though the cells are soundproofed, a soft clatter of noises from up and down the hall reaches William. Somewhere, someone sings. Water gurgles in the wall. For a long time, William listens while thinking of lost classrooms, students shining from within, their own light coming through, reaching for him in his darkness. Memories are vivid and sad within him. He thinks of that last class before he'd signed the contract. If he'd only known, he would have done more with them, he thinks. He would have slept less, thought deeper about each lesson, concentrated harder on individual problems, made a bigger difference. They will always be the "last" class, he thinks. There will never be another. I will never close a door again and turn to face the faces that wait for me to launch their adventures.

"Why do you keep scratching?" says the young man.

William flinches. The voice sounded loud in the tiny room. He stops his hands. "I didn't realize I was. Sorry."

The man's eyes are still hidden behind his hair. "You're pretty old to be in here, aren't you?" He doesn't wait for an answer. "Pretty small room for two people, if you ask me."

"I could be bounded in a nutshell and count myself a king of infinite space—were it not that I have bad dreams," says William.

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"What's that?" says the young man.

William folds the blanket at the end of his bed into a pillow and rests his head. "Nothing. A bit from a play. You're pretty young. I suppose I could ask the same question. What are you doing here, if you don't mind my asking?"

The man laughs nervously. "I killed my uncle." He pauses as if waiting for William to comment. "Really, I did. Or at least I think he's dead. I hope so."

William closes his eyes. The bed isn't too uncomfortable: a lump under his hip that feels like it will bother him if he stays on it too long, but otherwise not bad. "You want to talk about it?" William asks, half hoping the man will not.

"He deserved it," says the young man. "Nobody would behave any differently in my situation. See, he married my mother."

William opened one eye and looked at the man. "Really?"

"Yeah. He married her, and I think he killed my dad to get him out of the way."

With some effort, William sat up. "Really?"

"My lawyer says that he can get me off, though. He says I'm crazy. See, I told him that my dad's ghost told me what to do."

"Did he?" William's voice cracks, and the walls of the cell begin to vanish. Everything focuses on the young man sitting with his knees up, hiding behind his hair.

"But you know what's really crazy?" The man leans forward and whispers, "I did talk to my dad's ghost." The man falls back against the wall. "Now that's a story you don't hear every day," he says. "That's one for the books."

William rubs his hand across his chest as if straightening a tie. He looks around him. The cell doesn't seem that small anymore. He pictures some posters on the wall, maybe the Globe Theater. Perhaps a playbill or two. "That is an interesting story," he says. "Maybe I can tell one too. It might mean something to you. What do you think?"

The young man shakes the hair out of his eyes. They are bright blue and young, very young. They look like a student's eyes.

"Sure," he says. "I have plenty of time."

"Have you ever heard," says William, "neither a borrower nor a lender be? This is the story that it came from, and it starts with three guys talking about the ghost of a dead king. The king's name is Hamlet, and it's about his son of the same name."

They talk all night, and when Isaac comes in the morning to bail him out, William refuses to go.■

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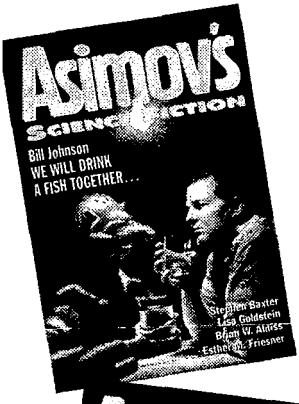

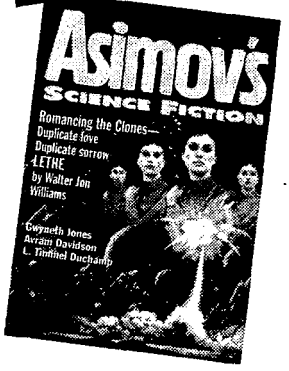

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Christopher McKitterick

CIRCLES OF LIGHT AND SHADOW

We don't get many second chances, and the few we do may come at extraordinary prices. . . .

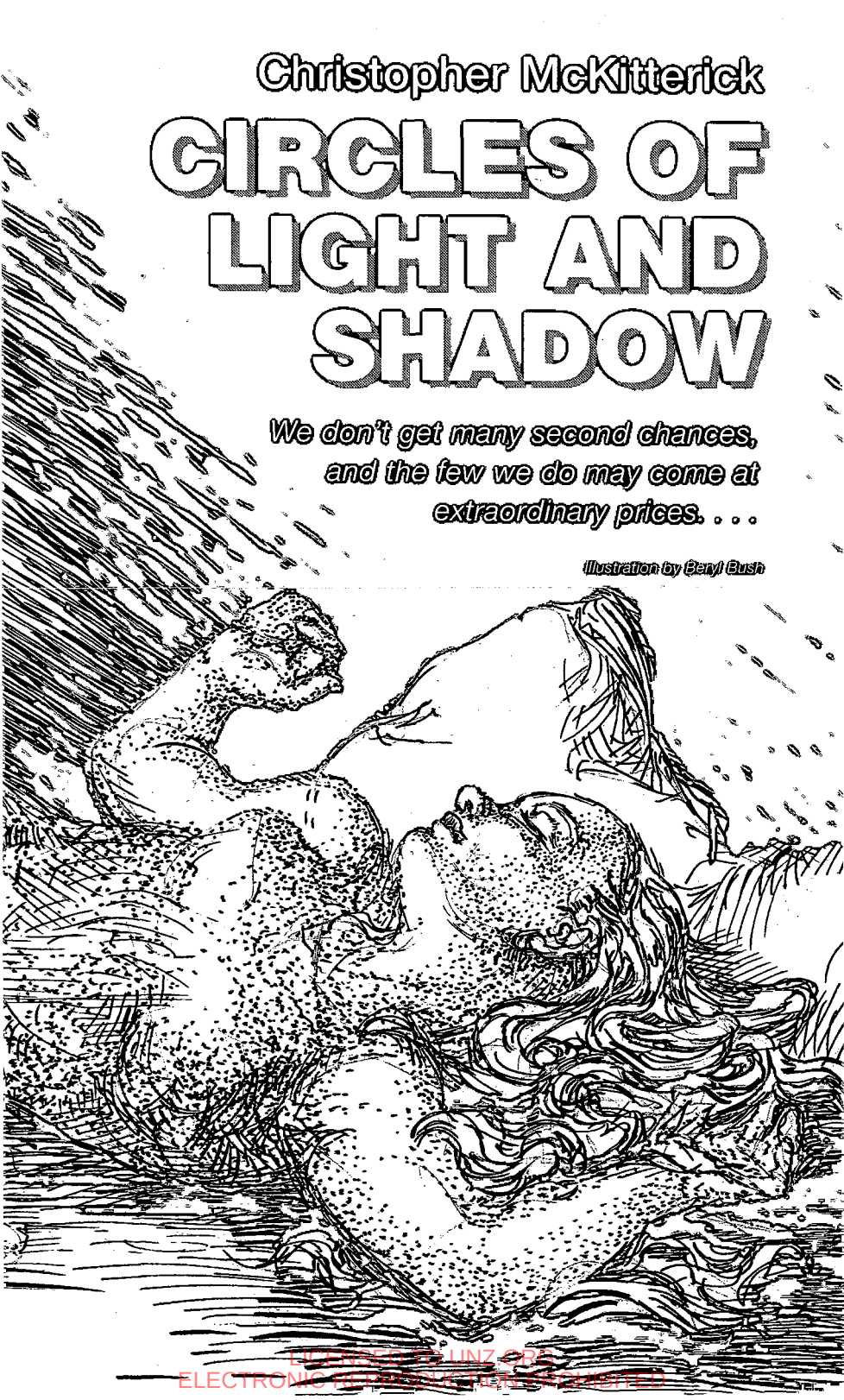

Illustration by Beryl Bush

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When the shadows started appearing—when things and people who had never even *been* before started appearing—no one knew quite what to make of them. Even I didn't, I who in large part was responsible for exhuming them. When strangers and the dead began to flash through our homes and public places, ghost tales abounded. I, trying to be a scientist, sought to understand. I was fiercely unwilling to accept that these flitting visions of faces were ghosts. Especially when my Laura showed up.

It was deep into a cold Wisconsin September night as I unlocked the door to our . . . the door to *my* house. Doesn't really matter.

I'd stayed late at TRI Institute, as I often did. Usually, I didn't notice the dress shirts tossed across the living room couch, the cat fur gathered in Betsy's favorite corners and chairs, the perpetually half-closed blinds that passed streetlight in upward-slanting beams against the ceiling and sent shadows at odd angles through the room. But tonight something was out of order. The familiar takes on shades of the alien when it has shifted out of position, even slightly.

At first, I couldn't put my finger on it. Betsy purred and rubbed her cheek against my leg as I removed my overshoes. As usual. Had the kitchen light burned out? No, I distinctly recalled having forgotten to leave a light on when I left that morning, since Hugh had called me during breakfast from the Institute and I'd left in a hurry. I walked into the kitchen and flicked the light switch, transfiguring the grey room into tan wood and yellow paint and soiled dishes.

Betsy gave an insistent meow near her bowl, so I filled it. The feeling of disjunction that had gripped me slipped away. I opened a bottle of beer, grabbed a granola bar from an open box on the crowded table, and returned to the living room to fall asleep on the rocking chair in the company of newsmen.

For some reason my mind began racing. I was having an argument with Laura again, only this time it was about the Volvo.

I awoke, startling Betsy from my lap. We had never owned a Volvo, hadn't even considered buying one. Laura was a Camaro woman, buying a new one every three years whether or not we could afford it, and I wouldn't consider parting with my 1960 Chrysler Saratoga.

Then she was standing before me, fists on broad hips, face pinched in fury like a walnut, screaming through nearly clenched teeth. And I could see outside . . . through her.

"Laura?" I said aloud. Then, "Ah, crap."

I'd seen my first shadow, my first ghost. Laura had been dead for nearly two years. Five hundred and sixteen days and—I looked at my watch—one hour, forty-five minutes or so.

Odd detail was, I couldn't hear her *words*. Yet I understood the argument as if I'd been participating in it for years. We'd married twelve years ago. Now I was thirty-six and none of this should've been happening.

She stood, just like so many old times, howling fury into my face at two in the morning. The talking head on the television news channel spoke authoritatively about a mass "ghost sighting" in Berlin. A family which had perished in the Holocaust attended a civic meeting; not your usual ghosts, they'd brought along a whole crew of children and grandchildren to argue for upgraded sewers. The popular theory among the witnesses went that the Berliners were being punished. I fumbled with the remote and muted the volume. The Germans weren't yet blaming us at the Institute; the leak about our project hadn't yet spread that far.

Now I could faintly hear Laura's words. Did she hate me so much in life that she was here to haunt me now? Bah, ghosts. But the difficult part to understand was that I knew *my* side of the

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current argument inside and out. She was clearly wrong; I wouldn't sell my Saratoga just because we couldn't afford to insure three cars. She was the one who wanted the Volvo, in case she got pregnant. Fat chance. You have to copulate to make a baby.

"Why don't you just sell that Camaro?" I said, as if I were really involved in this shadow argument, as if it could concern me.

I tensed to full attention because I hadn't intended to respond. I felt possessed—as I later learned, this was another common symptom of the rampaging discontinuity sweeping the globe. Absurd, yes, but what the hell else could it be? Utilizing scientific method, I struggled to find an answer.

Hypothesis: I drank too much. Bull. I only had two beers.

Hypothesis: I'm losing my mind. But I couldn't be a reliable judge of my own sanity, and I didn't dare ask anyone else if they thought me nuts. And I didn't dare go to a psychologist to be evaluated, since the Institute might be endangered if its director were mentally unstable.

Hypothesis: I've been working too hard. Evidence: Hugh is always telling me so. I'm at the Institute at least twelve hours every day, plus the hour commute to and from this house in the ruggedly beautiful Dells country, this one house of a hundred recently thrown up by developers who didn't realize that what people wanted by moving to the wilds and forest was trees, so they'd bared a swath of forest and levelled the hills and turned the country into suburbs bordered by wilds. Laura had hated that, but I was happy enough to be out of the city and among neighbors who didn't bother each other.

I realized my mind was drifting and gave up. Some people got thrills out of believing these visitations were God's punishment for humans becoming too self-glorifying, for our too-rapid scientific advances, for our playing god; or my favorite, that we had entered the end-time, that Armageddon cast its shadow-centuries across us.

Betsy called me from the kitchen. The instant I rose from the chair, Laura faded. I even forgot my internal monologue, my defense against her screams. Even so, I couldn't help but recall how I had been so wrong back then, when we were together. The way to end her fury had been so simple, but I'd been blind. All I would have had to do was recognize, in myself, that she was—once again—upset how little time I left for her after directing affairs at the Institute, helping the scientists write their papers on our progress of opening quantum peepholes into the future, on and on.

It was the oldest story in the book on marriage: One has important duties, the other feels ignored. Ignored, the other grows angry and the one finds other things to fill yet more time . . . like working on the Saratoga, which could eat all my free time if I let it. Relationships under such stress creak and fracture against one another like tectonic plates. Pay attention and ask questions. Try to understand. Communicate.

Ah, how often I had wished I could transmit that simple message back to a past self. The rules were so strict about passing information back that we didn't even know how to do so; no research had gone into it; we were encountering enough troubles firing into a future which supposedly possessed our technology. They'd need a tachyon receptor in the first place, and most of the past simply doesn't have one. Still, how many times had I stood atop the toric tachyon generator and fantasized that I could simply hook up a microphone, direct the tachyon pulse at the precise location in space where I had stood two years prior . . . hell, make it when Laura and I had fought our first battle of wills, before everything had melted to crap, before the outcome of our arguments had seemingly become life and death. I'd pick up that microphone and shout,

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"Listen up, William Sordera! She's not acting like it, but what's actually bothering her is that you're not paying any attention to her. You're doing the exact wrong thing by pulling back farther each time she screams. If you care about your wife and want to keep her, show it. Over and out."

"Dammit," I mumbled as I refilled Betsy's bowl. Doesn't matter now.

Betsy was eating too much. She was getting fat. But, as I blinked, I noticed that Betsy wasn't in the kitchen after all. Her bowl wasn't indeed empty. In fact, I had spilled cat food onto the floor.

I didn't sleep well that night. I never did when I tried to occupy our bed rather than my La-Z-Boy. So I drove to work early. I had already shifted two "Late" piles to the "Out" pile by the time Hugh entered my office.

"Hey, Will," he said. He held a number of open nine-by-twelve manilla envelopes under one arm.

Sunrise and dust made the room look as if it were made of solid nitrogen, vaporizing in the rays of the sun. I preferred to use only a desk lamp and, when available, sunlight. A long time ago I hadn't minded fluorescent bulbs.

"Morning, Hugh."

He shut the door behind him, moved a stack of science news magazines from a chair, and sat down across from me. He was a big guy, more muscle than fat, and I'd always wondered how he kept himself so fit working in a lab and swimming in the lake only a few times a week.

His presence forced me to set down the pen I was using to sign yet another grant request. Since the leak about the project three days prior, we were starting to run into resistance for funding. The Christian Fundamentalist Union had begun claiming that our experiments with the tachyon generator were responsible for the ghosts. "That's like saying a church service in Milwaukee today is responsible for the sinking of the *Titanic*," I had written to our senator who had once been so free to supply funds. In an ironic twist, we were forced into arguing how negligible an impact our work had on the environment. Well, we made a hell of a lot less mess than the supercollider, and even that was less damaging than your average Hurry-Lube station. Anyhow, we were transmitting into the *future*, which freed us from fears of paradox-generation. We weren't even sure the equipment was working properly; if it was, then why weren't we answering? Surely we'd soon have the capacity to reply.

"How long have you been here?" Hugh asked. He flipped through my remaining "Late" stack. "Seems you've done a bit of catching up." His big, green, Irish eyes narrowed as he caught mine, but he waited for me to speak.

"I know what you're going to say." I took off my glasses to rub knuckles against eyes.

"Then I won't say it." He stood and walked to the window, avoiding heaps of old journals and paperwork that should have gone to the recycling center long ago. The first yellow rays of sun were beginning to pierce the pink glow.

"When are we going to take that fishing trip up north?" he asked.

"Fishing trip?" As soon as I spoke, I remembered the conversation we'd had not long ago about how we both had once loved to fish but hadn't had time to get out on a boat for years.

"Oh, right," I said. "Well, this is kind of a precarious time, with funding in danger and—"

"Will," Hugh said as he turned and leaned against the windowsill, silhouette framed with sunglow but face lit by my desk lamp, "when's the last time you took a vacation?"

"Here we go," I said, pivoting my chair so I faced the computer monitor.

"I mean it, man. Really, you need to take some time off. I came here around midnight last night to pick up my wiring bag and guess what I saw? Light spilling

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out from under your door. I come in early this morning to return the bag in case someone else needs it, and guess what?" A moment of silence filled only by the tapping of my keyboard. "Did you even go home?"

"Nosy bastard," I said. Hugh laughed and headed for the door. I quickly added, "And, yes, I did go home last night."

He ignored me. "Oh, I almost forgot. Here's a letter from some minister of a Baptist church here in Madison. Says his flock wants to know why we're summoning ghosts. And he's not the only one thinking along those lines."

He shook the envelopes. I made a grunting noise.

"Do you suppose the tachyon beams are affecting time in some way we hadn't predicted?" he asked. "Raising the dead?"

"Doctor of Physics Hugh Donegall," I said, turning from the screen to cast a frown at him, "have they gotten to you, too?"

For just a moment, his face distorted in a way I hadn't seen before. "I guess not," he said. "See you at the noon meeting." He set down the letters, left, and shut the door.

That was when I, too, began to wonder. For the past few days, I had worked so hard at arguing against the blatant, utter stupidity of the idea that we were responsible for a worldwide plague of ghosts and possessions, that I hadn't for a second stopped to wonder if it were actually possible. I hadn't entertained the idea that, though perhaps incorrect in their analysis, our accusers were correct in their diagnosis. But how could the future affect the past or present?

I convinced myself that it would be unscientific to simply discard a hypothesis without testing it, and leaned back from the desk, deep in thought.

The conference table held the full complement of our professional staff: six physicists, twelve interns from the UW Madison, a visiting historian who wanted to be present should our research pay off with a reply from the future, and the two head electricians (both longtime Ph.D. students in physics) who were probably more valuable to our work than any of the rest of us.

"How can you say such a thing?" asked Sue Roosevelt, one of the visiting particle physicists. She held her cafeteria fork like a dagger. "Don't tell me you're going to let them take us down!"

"Of course not," I said. "What better way to prove our innocence than to disprove the loonies' claim that we're responsible for what's happening in the world?"

"Will's right," Hugh said. I'd been wondering when he'd chime in to back me up. He looked very serious, his heavy face rigid where it was usually expressive. He counted off on his fingers, "One, we know there's some kind of phenomenon, right? Two—"

"What proof do we have?" Roosevelt interrupted. "I'll bet it's all a big media fake, set up by those—"

"How many of you, here, have witnessed this . . . phenomenon?" I asked.

All eyes turned on me, then a few began glancing at one another. The fluorescent lighting cast a ghostly white across their faces—men and women looking like scared little children. A couple of the staff began to pay special attention to their lunches, silverware clinking against plates. I thought so. I felt secure in continuing.

"I've seen it myself," I said. "How many of you have, too?"

"*You?*"

"Don't pull my leg, Will. . . . "

"Do you mean to say that you believe . . . "

"What did you see?"

"I thought I was losing my mind, but if you . . . "

"All right," I said, "from now on, you're all on duty to test this hypothesis at all times. Watch for news stories that pertain to this case; god knows there are

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plenty of *those*. Keep your eyes open for clues and take notes. Listen to sidewalk conversation. We won't know what's important until we have the evidence in our hands to process."

"But that's simply not scientific," Roosevelt said.

"Anecdotal evidence is legitimate if it appears in sufficient quantity. *Everyone* can't be crazy. And if so, well, that's evidence of something, too."

I glanced from one person to the next, watching the faces of people I thought I knew were clearly hiding information. Slowly, tension eased.

"Any questions?"

This time, there was no outburst. Now they were all big boys and girls, and ghosts wouldn't scare *them*. Now they were scientists again, and they had an experiment to perform. I suspected the Institute's productivity would shoot back up.

It felt good to be back behind the steering wheel. The conversation's volume rose as one of the world's brightest think tanks was freed from fears and able to speak aloud on a subject previously taboo. Strange that a group like that had felt bound by the same taboo as the rest of society.

Or maybe it wasn't so strange. Top physicists aren't supposed to seriously debate the nature of hauntings.

The sun was setting on the other side of the Institute, and from my office window the sky looked violet, nearly black. As I leaned back in my chair, hands cupped behind my head, I imagined the sky glowed ultraviolet and I could see across the entire electromagnetic spectrum. A garden of color erupted across the galaxy: dull infrared stars, nearly dead and spent, blazed scarlet; supergiants grew so bright one could barely look upon them without pain; the core of the galaxy exploded like a Chinese lantern powered by atomic fusion, so gloriously stretching the limits of the rainbow as to blind any small thing such as man. . . .

I remembered one warm Wisconsin summer day, Laura and I out for a drive in my Saratoga. The car was long and low and green with tailfins that tried to act like rudders as we sped along country roads looking for the perfect spot. The big V8 rumbled before us, the forest-scented wind roared in through open windows and inward-turned vent glass, and Laura sat close to me on the silvery upholstery. Little golden lions were stitched into the trim, and the instruments were housed within a plastic dome out of which sprouted the steering wheel. I loved that car. Sometimes, though I never told anyone, I pretended it was a jet—it looked enough like one, only missing the wings—or, better yet, a grounded spacecraft. I only needed to find the right fuel and repair the rockets, then I could launch into space.

But that was when I was much younger, when I'd won the car in my Minnesota hometown. The local radio station had held a contest. Whoever could solve the riddle—actually a series of riddles, each a clue adding to the previous one—would know where in town the key that fit the Saratoga's ignition had been hidden. I found the key on the fifth day, the day before the D.J. would have simply told his listeners where to find it, and he who was fastest getting to the hiding place would have won. Where's the fun in winning when you don't solve the problem yourself?

That had been high school. But, before our senior year of college began, with Laura beside me, I felt once again that I had found a key—a key this time that would allow me to release all the potential of this fantastic automobile, and it would transform into a jet that could carry us to exotic, romantic places all around the world. Laura wasn't the key herself; rather, the key was something intangible created between the two of us, crackling electricity.

We parked alongside a narrow, lazy river embroidered with pine trees and punctuated by sand islets. The road that

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led here was crumbled tar, and we fancied we had discovered this place. Looking back, I know many must have visited there before. Why else would the beach have been so well maintained? No washed-up branches, no beer cans or Styrofoam cups, no poison ivy. . . . In fact, the little patch of short grass where we laid our blanket looked a bit manicured.

No matter. What was truly important was that we were together on a glorious day and we were young and the world was still indistinct . . . not the way it later gains definition during those chiseling years of marriage.

"So," I said, feeling strong and reckless. My bravado faded as I recognized the enormity of what I was about to say. "What do you think . . . um . . . "

Laura didn't say a word. I think she knew. We'd been together and monogamous for nearly a year.

The sun was warm on my face and bare chest. Laura's lap was soft. Her fingertips absently stroked my skin. Birds and insects wove a hypnotic background pattern, timeless and penetrating. I could barely hear the water brushing past the shore, only a few strides from my feet. The wine and sandwiches were comfortable in my belly. The scents of dust and pine and wildflowers and rivermist and the faint aroma of Laura suffused my head. I felt fear melt and courage return.

"I was just thinking," I said. "How would you like to get engaged?"

She laughed then. I rolled onto an elbow to squint up at her. Her dark hair was tucked beneath a straw hat which protected her pale skin. Her indigo eyes were barely visible in the contrast of hatbrim shadow and bright sun across her white blouse, unbuttoned far enough that I could see the lace of her bra and the rise of her breasts.

When she had finished laughing, she said, "Engaged, huh? Silly boy. I'd even go so far as to marry you, eventually. You'd have to ask, of course."

Asking was always difficult for me. Except for certain questions. Hell, in class, I was always the one who raised my hand when the professor said something that seemed absurd or something I didn't understand. I was still hoping to be an astronomer, then, so I knew about asking questions to prove and disprove hypotheses. And I had begun taking my first journalism courses, so . . . Well, for some reason, I'd always had trouble asking what Laura would later term "the important questions." In my determination to win our arguments, I would usually respond with something like, "But what could be more important than discovering the basic nature of the universe?" or "How can a question like, 'Honey, do you mind if I stay out with the astronomy club until dawn?' be more important than, 'What is the Grand Unification Theory?'"

I suppose I could blame it on my parents for never asking questions, always making demands; on my mother's tendency to term a child's question "stupid" when he simply hadn't yet read all the pertinent texts or attended the lectures. But that's just blame. Doesn't matter. It doesn't change what happened later.

I felt as if I hadn't taken a breath for minutes, staring out at the now-black sky—at least, as black as the sky gets this close to Madison. My shoulders were stiff from gripping my hands behind my head. The chair felt suddenly uncomfortable. I stood and stretched and breathed deeply.

A voice startled me: "It was easier when it was just things, wasn't it?" Hugh asked. I hadn't heard him enter.

"But then . . . " He paused. "You saw Laura, didn't you."

My mouth opened but I couldn't say anything. Hugh nodded slightly and sat down in the chair by my desk. I leaned against my reference bookshelf.

"At first," Hugh began, "we had a garden. Acres of tulips, just like Elaine had

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wanted when we first married. She still talks about it every spring, wanting a yard full of tulips, but who has time to tend anything bigger than the garden she has now?"

I had seen their house—Laura and I used to go there on Saturday nights—sidewalk and driveway framed by what looked from the highway to be film exposures of some star's light spectrum, a pair of rainbows stretching from street to house, stone paths breaking up the strips like Fraunhofer absorption lines.

"Well, now we have this magnificent, multihued ocean of tulips surrounding our house as if it were an island. Of course, the cold's hard on them. They're dying. But the damnedest thing is that we can almost never get a whiff of them—though more as time goes on, of course. We certainly can't touch them, although Elaine says that when she bends down and closes her eyes, she can feel damp petals against her lips."

I must have been frowning, for Hugh explained. "We never planted that garden. It appeared soon after everyone started seeing ghosts last spring."

"Well, it sounds kind of nice," I said.

He smiled one of those big smiles I hadn't seen him put on for some time. "Damned straight! Though it bothers me a little that Elaine's starting to believe we really did decide to plant it, that it's really *our* garden."

His smile faded completely and was replaced by that faraway look again. There was more to his concern.

"That's not what you meant, though, is it?" I asked. "You said, 'It was easier when it was just *things*.' What does that mean?"

He nodded, but his neck stopped before it had come fully upright, rust-colored curls blocking his face from my view. "You remember when Elaine had her tubes tied?"

I guessed then what was coming; I nodded.

"Well, this is how I started wondering if maybe we were affecting the past in some unforeseen way. I don't know." He didn't say anything more, just stared at the speckled floor tiles.

"So there's a child in your home now," I said, as gently as I could. I sat back in my chair across from him. Hugh had taken it awfully hard when Elaine had had her second miscarriage—a bad one—and decided to follow doctor's orders and make sure they couldn't try a third time. That was five years ago, two years after I had joined the Institute as Assistant Director, a year before old Matsuoka retired and the Foundation Committee had named me Director without giving me an assistant. Three years before I lost Laura.

Hugh's face flashed up to stare at me, eyes red-rimmed and intent, mouth pinched. A long time passed. At last, without saying a word, he made one quick nod and got up to leave.

He faced the door as he spoke. "You know, I'm not sure if this is a curse or a blessing, as the fundamentalists would say. I remember the day Elaine and I decided to try again. I remember the pregnancy, the premature birth, the weeks little Brian spent in intensive care. I remember his first steps and how elated we were that he was developing normally. Dammit, Will, I remember taking him fishing."

He took a deep breath, let it out slowly, opened the door, and shut it softly behind him.

I got home early that night, before the local ten o'clock news had wound down. With Betsy purring sleepily in my lap, two empty bottles of Leinenkugel beer on the side table and a half-full bottle in my hand, and a plate of cheese and crackers on the floor beside me, I stared at the TV. I couldn't hear it, though. My mind was too busy contemplating this new twist, that our facility may have somehow stirred up the ghost world.

But how? Even if it could raise ghosts, how could a tachyon beam aimed safely into tomorrow put a garden where

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there never was one? There had to be more to it than that. I ate another cracker with cheddar, took another swig of beer, and watched the meteorologist point at her map. The backdrop shifted to the weekly forecast, and she said something about how rain might spoil the weekend . . . when I was struck by what should have been obvious.

Possibility. We had a sixty-five percent chance of rain showers for Saturday, less for Sunday. No one could change that, not with today's technology at least.

But what about the possibilities in our daily lives? To atone for "being a shit," as Elaine sometimes said, Hugh might have splurged and hired landscapers to create that tulip ocean she had always wanted. Certainly the thought had crossed his mind; he just never quite made the choice, so they never had a garden. But what if he had gotten in bad enough trouble with her? He might have decided that was the only way to get back in Elaine's graces. At another decisive point in their marriage, Hugh and Elaine might have decided to screw the consequences and try a third time to have a baby. Small factors might have gone differently, leading them to get her pregnant instead of eliminating the option entirely.

Light cones, possibilities. In clarifying Einstein's physics, Stephen Hawking uses a simple model to represent how information might propagate from a point in four-dimensional space. As we drift along through space and time, we—as human points from which the courses of our lives diverge and converge—drag along a four-dimensional cone of all possible events that make us who we are, just as a cone of all possible futures radiates out from us at the speed of light—the fastest speed information can travel. Like ripples expanding across a lake from a point—say, where a stone was tossed into the water—our possibility cones expand over time. And since we, the pivotal points, do not exist at just one moment—say, the moment when Hugh and Elaine decided to have the tubal ligation—our ripples extend at the speed of light as our linear time flows onward. At any moment, we each stand at the neck of a vast hourglass of possible pasts and futures. That one decision, five years ago, caused a ripple that, today, would be the equivalent of five light-years across. If they had decided differently . . .

Why not?

I picked up the telephone and dialed Hugh's number.

"Light cones?" he asked. "What are you talking about? That's just a shorthand for describing the transmission of information, applied to—"

"Don't be so literal," I said, recognizing the fundamental difference between true scientists and myself. "What if we're altering the fabric of timespace every time we send out a tachyon pulse? What if every person we see in our daily lives is but one manifestation of all possible who-they-could-be's? Then it wouldn't matter which way we shot out our test beams, because the cones intersect over five dimensions. What if our tachyons have somehow torn the boundary between universes so that our various light cones are starting to coincide in four or even three dimensions?"

"Will, have you started smoking dope?"

"Knock it off," I said, standing. Betsy dropped to the floor and began to lick herself as if I'd hurt her, though it was only her pride that'd been damaged. "Don't be so closed-minded. Consider it for a moment. Each alternate decision would have propagated another, distinct, light cone—a possibility cone—that might never intersect the first."

"It's awfully self-centered to think we're 'creating' universes. Like Aristotle's view that everything in the universe rotated about the Earth."

"That's not what I'm saying," I said. "In fact, those other possibility cones, past or future, might have created us. Doesn't matter. What matters is that our

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research might be slicing up the space-time universe so that all the included little universes are coinciding. What might that do? You, yourself, said that Elaine's garden is becoming more tangible. What if the overall mass of the universe is increased beyond some critical limit? What does it mean to us, today, if that's happening? What if the mass of heavy metals suddenly increases and things like uranium tied up in the soil begin to—"

"Will," Hugh said, "relax a moment. Go to sleep. This is certainly an . . . intriguing hypothesis, but let's wait until tomorrow's lunch. Maybe one of the others discovered some piece of evidence that'll lay your fears to rest, eh?"

"Maybe," I said. We spoke a little longer about things that didn't matter, or I simply can't remember, and said good night.

Another beer and I was almost relaxed enough to sleep. I turned off the sound on the TV and closed my eyes.

I experienced another haunting. Nothing supernatural this time, just the same old memory that I'd been beating myself up with for the past two years. Laura and I had just concluded a particularly bad fight—or maybe it was of the usual intensity and only now felt worse because of what happened later. No matter. I can't even remember now what it was about. Of course, what we thought it was about at the time wasn't the real topic.

The worst ones always happened late at night, when we were supposed to be sleeping. Back then, I was accustomed to getting eight or more hours of sleep. Later, I discovered I only needed seven, then six, until at some point I was functioning perfectly well on four and three cups of coffee spread throughout the day. A man who's not ready to grieve must work hard to wear himself down so he can reach the level where he's weak enough to succumb to emotional pain. I was unable to reach that point, no matter how little sleep I had, no matter how poorly I ate, no matter how empty the house felt when I came home in the dark, lonely quiet. All throwing myself into work really accomplished was to consume my energy and attention and send me home so fatigued that I hardly had time to think, much less grieve.

So we were hurling words at one another. Doesn't matter what those words were; suffice to say that they were loud, had little to do with what the other person was saying, and were intended to be more injurious than they were. The same fight a few years prior would have been paralyzing. The same fight during our first year of marriage would have been wrapped up in divorce court. Interesting how marriage is like martial-arts training: If you get hit enough times, it no longer hurts. If you punch a heavy bag enough times, your knuckles get tough and calloused. Some masters have been known to pound on boards or metal plates.

Usually, such a fight would end when something of mine, in another room, broke. I always cringed during the wait between her storming out of the bedroom in exasperation and the crashing sound. Then Laura would return to bed, yank the covers off of me, and go to sleep without another word. The next evening usually ended with my apologizing for what had set her off in the first place. For instance, "Sorry that I didn't call to let you know I'd be working late." Of course, *I* never heard an apology.

What I really should have said was something like, "Sorry I behaved in a way that made you think I didn't care how you felt." Better yet, I should have called at first, when she would have expected me home. Or, best of all, I should have just gone home.

Should, should, should.

I lay in bed, body tense as I waited for the cymbal crash that would signify the end of this scene. Instead I heard the

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front door slam. That went completely against the script. Then I heard the garage door open. I got a little concerned. Naturally, my concern was not for Laura, not yet. I was concerned for the Saratoga. That particular something of mine had a lot of pieces to smash.

She hadn't destroyed anything of mine that really mattered since I lost my model X-1 rocket plane; that had been after a really bad fight, though. That was when I was actually moving my stuff out to a grad school buddy's place, and she came home to find the apartment half empty. But that was also at the beginning, during our second year of marriage, when I had gotten too hurt by her always asking, "Do you think we should stay together, or would we be happier apart?"

I remember the tears in her eyes as she said, "Don't leave me. I didn't mean it that we should split up. I was just trying to get your attention." But I couldn't hear her. I picked up my last box and went to my friend's apartment. When I returned home the next morning, after spending most of the night holed up in my friend's spare bedroom on the phone with Laura, I found our framed wedding picture on the stairs and fragments of the X-1. We had more wedding photos, but that rocket plane had cost me dozens of hours and hundreds of dollars. I had actually built an operable liquid-fuel rocket motor for it, though I'd been afraid to test it and destroy the model.

But the Saratoga was bigger and more important. It held nearly two decades of sentimental value. It was the car I had used to court Laura. To damage it would be a symbolic way of irrevocably damaging the relationship. Pictures and planes can be replaced, not memories, not marriages—at least not as easily.

I ran outside in my nightshirt only to watch the tail lights of Laura's Camaro shrink like angry eyes into the midnight dusk of streetlight and windowglow.

I distinctly recall my mind generating the image of a calloused fist striking something that, unexpectedly, had been soft and vulnerable; words are sometimes harder than emotions. I have no idea what I might have said that could have reached inside Laura in that mood. It certainly wasn't intentional, never was; I suspect I only said things aimed simply to stir her anger, not actually hurt her. Even so, as I watched her drive away, I had a flitting hope—like every sparring partner in the midst of a particularly knock-down fight—that she would crash and die, leaving me to peace and quiet, to pursue my work without the drain of our seemingly continuous fights. I pictured the face of one of the Institute's young female interns, who was blatantly enamored with her new director. . . . Freedom and peace and quiet, and no fear of losing more possessions to Laura's spite.

I went back inside. With a grin pasted across my face, I suppose, muttering something about how lucky I was she'd gone and I hope you never come back, goddammit!

A Wisconsin Highway Patrol car pulled into the driveway sometime before dawn. I hadn't been sleeping. That fantasy of a life without Laura had grown less attractive as the hours stretched on and the garage door hadn't opened.

Doesn't matter what the Highway Patrolman said. What matters is that my fantasy had come true. My wish had been granted.

Hallelujah. I was a free man.

Crap.

I don't know how many times I replayed that night before I fell asleep. That weak time between the third beer and dreamland was when I usually replayed the old tape. Slam goes the front door, grumble goes the garage door, *vrrrrrrrrr* goes the Camaro. And, yes, I did hear a crash that night. The imagination always creates more vivid movies than you see on the screen. For a few weeks, the only way I could fall asleep

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was with a six-pack of Leinenkugel under my belt. Hugh had made sure I wasn't drinking alone for a while, but Elaine got a little tired of that. I understood. No matter.

So, there I was, lying awake in bed, thinking about the night Laura left me for good, just like I'd hoped she might. Stupid to be in bed, I told myself. Always the worst in bed. The air smelled musty, like old sheets. The room was a complex pattern of greys cast from wrinkled shades and mirror reflections of light that carried from the hallway. Streetlights.

And then Laura was with me again.

I must have gasped, for she looked startled and opened her eyes. She was riding me in that slow rhythm that drove me wild with the need to buck but felt so good that I didn't dare move, I so wanted it to last forever. Laura smiled in a knowing way, mouth closed and nostrils flared, breasts tickling gently against my chest. She was older than I remembered her last being, and more beautiful than any woman I had ever seen.

Hesitantly, I reached up and held her by that notch between hips and ribs. I gasped again. I could *feel* her. This was so much more real than the previous experience, and I began to wonder how many of the world's hauntings had been this substantial. No wonder this plague was making people go mad. But at that moment I would've destroyed my reputation and work if it meant keeping this phenomenon in operation.

I smelled her sex, her sweat, the sweetness of her hair hanging against her cheeks. I felt her warm slickness, the weight of her body on my pelvis and thighs and shoulders. I heard her breath coming faster and harder, her body smacking mine. I tasted her in my mouth, as if we had been making love all night. And, of course, I saw her. She was an angel of light and shadow. She was the Laura I proposed to along that slow Wisconsin river.

All the barriers were down, so we hadn't had a big fight for at least a month. I wondered why the previous night's haunting included a fight, but not for long; something must've gone wonderfully right since then. We were vulnerable enough to one another that we allowed such pleasure to pass between us. No anger. No petty recriminations. Not even a reservation. We moved together and all was right in the world. I could've cried, I was so happy.

Our passion accelerated, heated, exploded, and began to cool and ebb. We lay nestled like spoons on the bed, and I listened to her slow breathing. I knew—for I somehow held at that moment, in my head, all the memories of a life I hadn't lived—that this was the best lovemaking we'd had since that night Laura had come home from her reckless bout of midnight driving two years before.

And then I knew this was wrong. Laura—*my* Laura—had died of massive internal hemorrhaging. There had been no lovemaking.

I was as terrified as a little boy who sees a shadow in a vampire's graveyard. I dared not move or speak. Something was terribly wrong, and now I understood why superstitious people were calling this the end of the world. For, truly, the dead walked among us.

I couldn't sleep. I simply lay there, one arm around Laura's waist, my body pressed against her length, sensing every breath of her, electric before me, and savored the ecstatic terror.

Sometime before sunrise, my arm fell to the mattress. She had vanished. Maybe I cried. Doesn't matter.

I got to work later than usual. Hugh followed me into my office.

"Jesus, Will, you look like you've seen a . . . " He didn't finish the sentence, his grin fading.

"Not funny, eh?" He sat down. "Tell me about it."

"Laura was with me again last night. We made love." I couldn't say anything more. My head slowly shook from side

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to side, my jaw hung slack. I felt numb and sweaty.

"Elaine picked tulips yesterday," Hugh said. "When I got home, we had a full vase on the dining room table. What's going on? I'm almost willing to accept your theory."

"Hypothesis," I corrected.

"Dammit, Will, this is getting serious. Why don't you call the meeting now?"

I did.

Only Roosevelt and the two interns hadn't experienced any perceptible hauntings.

"You ever been married?" I asked the particle physicist.

"None of your business," Roosevelt replied. She frowned, a whole-face frown. "Why do you ask?"

"I'm toying with a theory," I said. Hugh looked up and a faint grin crossed his face as I used the more secure term. "I also suspect you've followed a rather direct path through life to this position at the Institute."

"If you're suggesting I've led a boring personal life . . ." She smiled, a rare event. "I wouldn't say it's been much more boring than your average person's. Why?"

I then explained my theory of light cones and alternate universes and the world filling up with the dead and flowers that had never been planted. I debated the skeptics with my tale about spending a night with a woman who'd been dead for two years—and feeling in my heart that she'd never been gone, knowing from experience that we'd argued and shopped for groceries and travelled to Mexico City since then. *Knowing* both that she had died and that she hadn't.

One of the physicists, a quiet man who nevertheless handled theoretical physics brilliantly, handed me a sheet of paper full of figures.

"It's, ah, not complete," he said, "and I haven't worked out the proofs. But what you're saying is possible."

An uncomfortable silence ensued.

"I suggest we shut down the generator for a while as a test, to see what happens," I said.

"No!" said Roosevelt. Such an outburst was very atypical of her.

"I wonder if maybe Doctor Roosevelt's past contains a ghost or two she's hoping will visit?" Hugh asked.

Roosevelt's eyes shot laserbeams at him, then she turned and faced her paperwork in silence. That, too, was unexpected. I began to wonder how much of this sort of thing we'd run into.

"We have to stop this phenomenon if we can," I said. "Who knows what will happen next? We might cause the entire universe to collapse in upon itself. Does that sound very attractive? Discussion."

After a few minutes of awkward verbiage, they began to sound like intelligent scientists brainstorming on a fascinating problem. I could lean back and watch, and hope for another night like last night. This time I wouldn't be afraid. No, I'd savor every moment.

When I got home—before the five o'clock news had started—my breathing was ragged and my heartbeat sounded like the pulse of a V8 on the highway.

"Laura?" I called out, feeling a little silly.

For a moment, dizziness swept through me. I swear I heard the sound of ripping cloth and felt the ground shudder. The shirts vanished from the back of the couch. The couch itself transformed into a leather affair and appeared beneath the picture window. My La-Z-Boy sat in the same place, with Betsy upon it. She looked up but didn't run to greet me. Her fur was ruffled, as if she'd just watched a catfight in the front yard.

"In here, honey," Laura called back, from the bedroom. "You're home early. I just got back from class. Be right out."

I realized why I'd felt an overlap the first time: Perhaps, just perhaps, one isn't pulled across possibility cones until one's mirror and one's self intersect

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completely, occupy the same virtual space. Thereafter, it would be impossible to do so, but the barrier between universes had been breached.

I removed my coat, hung it in the closet, and went to pet Betsy. She hissed, scampered across the room, and vanished into the kitchen. I hadn't bargained for this. Ever since I'd gotten her, Betsy had been the one creature that had granted me unconditional love. When Laura screamed and smashed things, Betsy would come to me and purr, rubbing her cheeks against me. Arguments made the cat nervous. During the time Laura had been gone, Betsy had been the one creature who laid with me at night and kept a spot of my body warm.

But when Laura walked into the living room, Betsy was lost from my mind.

"So, how come you're home so early?" she asked, smiling as if to say, "Yes, I remember last night, but I'm not going to say a word about it."

"I just wanted to see you." I reached into my shirt pocket and pulled out a card I had picked up for her at the convenience store on the way home. I had written a few lines inside about how much she meant to me.

Her face took on a lopsided smile as she read. She slid the card back into its envelope and crossed her arms.

"That was unexpected," she said.

"There are so many things I should say that I don't, and so many things I shouldn't that I do. It's time I let you know that."

She looked dumbfounded and shook her head. "Geez, what's gotten into you? Was I that good last night, or are you feeling possessed by the desperate Will again?"

She laughed. My face froze. "You . . . you know about the hauntings, too?"

She frowned. "How could you miss it? Geez, you're really acting odd. And why are you wearing those clothes?"

I could barely breathe. Oh, it was so simple: If we were experiencing the phenomenon, so would the alternate-light-cone people. Hell, if events kept progressing as they were, pretty soon there'd be no way to tell who was from which possibility cone and who were my contemporaries.

Worse, I was beginning to lose *myself*. All these alien memories were lodged in my head. I remembered the day Hugh called to help him clean the garden after the landscapers had left. But I also remembered Hugh telling me he had wanted to plant a garden but never had. I distinctly remembered getting another call from Hugh: "Brian took his first steps! Damn, he's *perfect*, Will, not a thing wrong with my boy!" But I also remembered the day he took off from work to drive Elaine to her surgery that assured she couldn't get pregnant.

The world was becoming pregnant, all right. But I'm not sure what was growing in the womb we'd developed, or what would happen upon birth.

"Will, what's wrong?" Laura said. "Something's wrong." Long pause.

"Oh my god, you're not Will, are you?"

I still could hardly breathe. My tongue ran across my lips, as if they needed lubrication to make words.

"Ah . . . it's a long story."

Her look of dread balanced with obvious curiosity. Obvious because she didn't run howling from the room. So I told her my theory.

"But you've been . . . I mean, *my* Will has been doing the same work as you have. Only he hasn't said anything about light cones or critical masses. Why should it matter—?"

"Oh, crap," I said. Complications to the possibilities. The meteorologist's chart just grew a third dimension.

"I've got to call Hugh," I said. "They have to shut down in every world where the Institute is generating tachyon beams. My god, we're going to kill ourselves because of our self centeredness. Aristotle, all right!"

I ran to the phone and was about to

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dial when I smelled the soap. Someone had recently washed the phone. This was not my phone. This was $Will_2$'s phone. Would it call *my* Hugh or another one?

My head reeled. I slumped against the hallway wall and stared at the photo of the five of us—Laura and me with Elaine, Hugh, and Brian in a field of tulips—that hung over the phone cubbyhole. The earpiece in my hand suddenly began to beep. I hung up the unit and stood in awed silence. What had we done? What could we do now to reverse it? And did we have time?

"Will? Honey?" Laura took a step closer. "You don't mind that I call you 'Honey'?"

"Of course not," I said, my chest hurting. What an incredible question. "You don't know how much I've wanted to hear that, for so long."

"I assume you and I . . . In your world, you and I split up?"

I almost told her the truth. No, I couldn't do that. I couldn't even think about that now. "We . . . broke up." My voice had the quality of a frog's.

Laura moved closer and tentatively placed one hand on my chest. "The card . . . ?"

I blushed.

"How long have you been haunting us?" she asked.

"I first saw you two days ago."

"That would explain my Will's sudden change of heart. And . . . last night?" She placed her other hand on my waist and her lips opened to pass more air volume as her breathing sped.

I couldn't resist this apparition. I told her I had been there last night, when she made love to another Will. She had made love to me, as well, and I to her. I told her I felt willing to destroy the universe just to be able to hold her again, even if it only meant for another few days or hours.

We kissed in that hallway the way we had when we were first dating. It was life-giving, empowering, while at the same time all-consuming. A sudden thought intruded.

"What if your Will walks in and sees us?" I whispered into her mouth.

"Screw him," she said. "I can't believe he and I are still married. But it doesn't matter now, does it? You are Will, even if you're a different Will. Right? So I'm not cheating on anyone. You're what I want him to be. So screw him."

Her lips fell against mine again and she absorbed my concern so that I, too, was thinking, "Yeah, screw Will. I know that Will. That Will is the one who wished you would have an accident on Highway I-90. And you did. Screw him. I'm here, and I've learned better. I know what you need, because hardly a free moment has passed in two years when I haven't gone over and over in my head how I should have been different. You're right; I'm the Will you need. Lock the door so he can't get in. Let him sleep on the cold, damp earth as my Laura has slept within it for two years. . . ."

Desperate, my grief rose up then and I expressed it by enfolding her in my arms, the very same but different woman I'd driven to her death; I expressed it with my mouth and tongue; I expressed it by pulling her blouse and skirt and bra and panties from her warm and firm and living body, by carrying her to the bed I had avoided for more than a year, by kissing her the way she loved best in the places she loved best with all the passionate energy of two years . . . hell, of a decade's mounting desire we'd barricaded from one another so high and thick and far into the past that the callouses made our interim sexual relations seem like plumbing work. This time, unlike the previous night, I harbored no reservations, felt no fear; this time, I knew she knew who I was, knew she wanted me, wanted her, and gave her my all and best.

When $Will_2$ pounded on the front door because the latch had been thrown—a latch that couldn't be unlocked from outside—Laura and I

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looked at one another and giggled like naughty children.

"Let the bastard try to figure this one out," I said.

Laura's smile shifted into that bad-girl look she'd worn so often when we were first together and her hips began to go wild beneath me. We *fucked*. That was the only term for it. We fucked, and, god, it was like nothing before. The pounding ceased after a while. We fucked again, then made love again, then lay quietly in one another's arms.

When the sweat had dried, Laura asked, "What was it? You know, that broke us up? I mean, you and the other me?"

My throat was dry when I tried to swallow. I couldn't lie this time. I told her. She didn't say anything for a long while.

"I'm sorry," she said at last.

"It wasn't *your* fault."

"Yes, it was," she insisted. "I remember that night. God, I was so pissed at you. And you know what made me the angriest?" She rolled over so we were facing one another in the dim illumination cast by streetlights through the open window. Her hair hung damp against her forehead. I wanted to take a photo. I did, in a way. I could describe every millimeter of her at that moment.

"What made me the maddest was myself," she said so quietly I could barely distinguish the words. "I wasn't angry with you. Well, sure I was. But mostly I was angry with myself. Every time I scream at you, I do it. . . . I'm sorry. Every time she screamed at you, she did it because she was so hurt by the lack of communication between us, er, you know. I went driving that night because I couldn't bear myself any longer. Do you know I only broke your things to get your attention?"

I nodded. I still felt the hurt from her behaving in those ways. She shifted and went up onto one elbow.

"Well, I was determined never to break anything again. So I had a chance to realize my screaming was only making you back farther away from me. I realized that, every time I acted like that crazy bitch mother of mine, I knifed my own soul. The scar tissue had built up so thick I barely noticed any more. I couldn't stand it any more, but I couldn't see any alternatives. I didn't want a divorce, but I couldn't bear going on the same way. I . . . "

When she didn't say anything for a full minute, I spoke. "What happened then?"

She shrugged. "I sped along the highway for an hour or so, pedal to the floor, narrowly missed a big buck deer . . . " Her eyes grew huge and she looked as if she were seeing a ghost of herself, shattered by a windshield. I wonder what it feels like to feel the thoughts of the dead.

"That must be when—"

"Don't think about that," I said. "Did you come home then? How did we clear up our problems?"

Laura sat up, pulling up the sheet to cover her breasts. "We didn't. Things got tolerable, that's all. You, er, Will saw a counselor for a while. So did I. I spent that night at Elaine and Hugh's. The next *three* nights, actually. Geez."

Her eyes softened and she faced me again. "But here you are. The Will I loved from so long ago, but not as young. How did you change so much?"

"I've had time to think."

She smiled a little, the sheet still obscuring her nudity. I felt exposed, so covered myself, too. We tried to cuddle for a while, but something had changed.

I knew what I had to do.

"I'll call Hugh," I said. She smiled and rolled onto her side. Laura. I felt the grief rise again and had to leave the bedroom immediately.

Hugh got out of his car and leaned against its door for a moment, the dome light drawing his silhouette distinctly in the night. He hadn't brought Will$_2$, keeping his word as usual. I wondered how

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this night might have gone differently had I come home at the usual hour, as before. Would both of us Wills have occupied the same space again, as we had before? Or were those moments of mutual "possession" only the catalyst for converging our possibility cones? If nothing else, coming home later would have meant that Laura and I wouldn't have spent that priceless time together.

"I'll be damned," said Hugh. "So that's what a 'ghost' looks like." He slammed his car door shut.

"We've got to talk about the tachyon project."

"You know about that? I suppose you would," he said, walking closer across my driveway to where I sat on a patio bench I'd never seen before.

"Does Laura know what's happening?" he asked when he finally stood before me.

I nodded. I felt a bit intimidated, as if this longtime friend might suddenly attack. He wasn't, after all, the Hugh I knew.

"It's good to see her again," I said.

He nodded and sat down beside me, looking up at the few bright stars visible from the neighborhood. "I'll bet. I'm in here, too, you know," he said, tapping his temple. He crossed his arms.

"Hugh?" I said. That was absurd, of course.

"Yeah, at least two of us, I presume. Tonight I had the oddest memory flashes. I assume I'm talking to the right Will? Your Laura," and he whispered the rest, as if my wife might be listening, "she died two years ago?"

"In a car wreck," I added.

He drew a deep sigh. "Then we have trouble. In my extra set of memories, I recall your spouting a theory about torn boundaries between light cones. Problem is this: Just how many alternate universes are overlapping, and how do we measure them? Only those that most closely parallel one another will overlap as thoroughly as our two . . . universes do. There may be thousands, hell, an infinite number more. We may be witnessing the Big Crunch or Big Bang or both."

He faced me and leaned close. "We may have created God in our tachyon generators."

I blinked. He might have been able to see my face or he might not have. The patio light was on, a dull yellow anti-bug lamp.

Then Hugh leaned back and bellowed in laughter. "Sounds crazy, doesn't it?" he said between gasps.

"I'd say. But it's not exactly what I'd call funny."

His laughing subsided. "I know, but if you can't laugh, you gotta cry. What do we do, Director?"

"Just what I said in the meeting today, if you remember."

He looked thoughtful for a moment and then nodded. I continued.

"Shut down and try to get all the alternate Institutes to shut down. Damn, and we'll have to make sure no one else builds more. Can you imagine? The newest kind of doomsday weapon. 'Don't mess with our country or we'll destroy not only your country but the whole universe!' What a goddammed mess."

"Jesus." He drew a deep breath. I wouldn't have been surprised had my atheist friend crossed himself in the presence of the galaxy pinwheeling overhead.

I started really brainstorming in my own, Director of TRI Institute, way. "The biggest problem I foresee is this: If we can't count the number of alternate universes, how do we communicate with them? We'll have to assume that a near-infinite number of universes have been created since the very first variable occurred in the Universe."

"Jesus."

"So we need to communicate with every one that has attained mastery over the tachyonic generator, since it's likely they're the ones that are causing the trouble and the only ones we can talk to, anyway. It's safe to assume no one in the

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past has done so, or the phenomenon would have kicked in before now. It's also safe to assume we humans are the first species in the Universe to have done so—we'll have to assume that, since I have no idea how to communicate with sentient stones. If this is their fault, all is lost."

Hugh gave a polite chuckle.

"So," I said. "You're the real physicist; I'm just the director. How do we go about telling everyone to stop cutting holes in the fabric of spacetime?"

"Will," he said, rubbing his chin, "the cure to this disease could be more deadly than the disease itself. Do you want to transmit a message back on a tachyon carrier-wave to ourselves and tell us to stop? There are good reasons we forbade that. I'd bet good money that you and I would not only *not* be having this conversation, but that we destroy ourselves so that we'll *never* be able to send that message back. Thereby allowing other selves to go on with the project and not stop their past selves. We'll create an isolated timeloop. Jesus, Will!"

Even as he spoke, I realized what we had to do. The team would have to figure out how, but I was confident they could. The only question was, could they reconfigure the targeting device in time? Hell, for all I knew, the Universe was in the process of collapsing at that very moment.

Nearly two dozen scientists, interns, and electricians were rudely awoken soon thereafter. Those who chose to let their answering machines shield them from their duty got house calls. Even our visiting historian hurried to watch the events. When all had safely arrived at the Institute, I drove to Hugh and Elaine's. I had some stray ends to tie up before my own, personal universe was destroyed.

I waited for a few minutes in the Volvo, beside another man's Saratoga, gathering my argument. When I felt confident, I opened the door to speak to Will.

He was waiting for me.

Now, we all like to think we know ourselves, at least well enough to calculate how we'll behave when faced with certain circumstances. But $Will_2$ was *not* me. He hadn't been me for two years. In fact, this universe might have been one separated by even more distant events. I would have chuckled upon recognizing my self-centeredness: Most likely, this universe was one created by some cosmic event like a local supernova. Who the hell knew? Doesn't matter.

What mattered was that I was facing a man whose wife I had just slept with, and it was only safe to assume he knew about the affair. If nothing else, he knew I'd been along for the ride the night before, because he'd be in possession of memories that bore no connection to *his* past. And he had also trained in the martial arts during high school and early college. Possibly he'd been training since. I began to wonder if this was a bad idea.

"Hello, Will," he said. He sounded like the cocky me I knew from my undergraduate days. Crap. He was as likely to kick my ass as discuss cosmology.

Nothing's quite as strange as meeting your double. Now imagine that double is, in every measurable way, indeed your exact double—nearly identical history and thoughts. I think that's what kept him from proceeding to pound on me.

I decided my only hope was to grasp the initiative. I knew that much about myself, that it was in my fundamental nature to listen when someone spoke authoritatively, though I might jump in to debate the first logical flaw.

"The Universe is about to be destroyed," I said, and explained.

He listened, then spoke. "I noticed how you hijacked *my* team to save the Universe. My best goddammed friend, too, I might add."

"Laura loves you very much," I said, and hurried to explain when I saw $Will_2$'s face began to harden. This time, he listened to all I had to say. As I spoke,

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my lecture grew impassioned. Epiphany enraptured me such that my every sense was heightened. I understood myself then, and I understood both Lauras, and I understood this Will. And it really pissed me off that he was still throwing away the very thing he most desired because he didn't know how to obtain it.

I realized that, even if I lost Laura forever, I'd still have her in my mind in as real a way as anyone can prove. *I possessed the memories.* So I wanted this bastard to keep her, if only so he would continue along a path I had followed, never mind that my trek had forked a couple of times. I could live vicariously with Laura for the rest of my life—however long or short that might be—through him, even if I couldn't share his future memories.

When his questions started getting mundane, I knew it was time to go home. There was nothing I could do for the team at the Institute until they'd done the technical work, and I didn't want to get in the way. Will's face hardened for a second, then something like sadness washed away the stone. I hoped it was a permanent wave.

I was about to leave when he said, "Take the Saratoga. I know how much we hate the Volvo."

We traded keys. Overwhelmed with sentimentality and synchronicity, I drove off in my old car.

I lay in bed beside Laura. The time had passed for frenzied lovemaking. We both knew our time together was limited, and we both knew that I was an intruder now. We all knew: Betsy still wouldn't come to me.

When I awoke with the sunrise, Laura's eyes were already open. She smiled and rolled closer.

"I don't want you to go, you know," she said.

"I don't want to go either, but it's out of my hands now. As soon as the generator's realigned and the transmitter's linked up, we'll all likely be scattered. That might include some painful shockwaves. Hard to say. But not changing things back is the broad highway to hell."

She went to the bathroom and returned a few minutes later, face washed and teeth brushed. She'd be leaving for classes soon, since I'd learned this Laura was a doctoral student in graphic design. My Laura's M.A. had been in art history.

When I rose to shower, wondering what progress the night had brought at the Institute, Laura stopped me with a kiss placed in the center of my chest. I didn't make it to the shower for another hour. We made love slowly. It was more psychologically painful than anything I'd let myself feel in longer than a year. I thought I couldn't orgasm, yet the emotional intensity made my build and release almost transcendent.

Afterward, lying beside her, I said, "Before, I forgot to tell you I'm sorry. I forgot to . . . forgot to say goodbye."

She rolled over and put her arm around me. I cried like a damned baby, cried for so long my head throbbed and my throat was hoarse. It was strange to weep at the breast of a woman who looked for all the world just like *my* Laura. I knew I'd never again make love to this living woman, whether or not my plan worked, whether I returned to my possibility cone or if I were trapped here for the rest of my . . . months? hours?

But none of that mattered just then. I felt relieved of a burden so heavy that, looking back, I wondered how I had managed to even function for two years. Perhaps I hadn't, if a man is more than his work.

At long last, I grieved for my lost wife.

By the time I arrived at the Institute, the team had made all the major modifications. Roosevelt, in particular, looked both haggard and terrified by what she was about to unleash. All morning, they came and went in a sweaty hurry

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through the control room where I shuffled paperwork. But at 11:27A.M., I noticed Hugh was simply toying with the keys on one of the input terminals.

"What's up with you?" I said. "Is something wrong?"

A number of the others shuffled into the room. "What's wrong?" I asked.

"Nothing," Hugh said. A pause. "We're ready."

I almost laughed, or maybe almost shouted. "Well, then," I said, "go ahead. And hurry; we don't know how much time's left." Strange to think of time like that, especially under those circumstances.

Roosevelt squeezed through the group and walked up to me. "Sir, Will, we . . . well, none of us has the guts to throw the switch."

"Ah, geez," I said, rising from the lab chair where I'd been doing busywork while they did the real stuff. I shook my head and grinned. Everyone waited until I had passed, and I led the way to the generator lab, through a bombproof airlock.

The cause of our troubles stood in the center of that utterly scrubbed white room, great serpents of multicolored wires crossing from transformers and power leads, rows of computers and storage machines lining the walls: The access tower of the toric tachyon generator rose from the concrete floor.

Suddenly it looked alien and deadly, its visible segment two meters tall, bristling with stainless-steel access rods. The crisscrossing cables terminated at points in the floor that corresponded with minicolliders inside the torus which was buried beneath the TRI Institute building. It hummed quietly, as if content. Of course, the hum came mainly from the computers' cooling fans, but every piece of equipment in that room was in some way part of the generator. So the sound indeed came from our Universe-crushing cybergod.

For only a moment, a thought crossed my mind: What if Hugh was right? What if we *had* created a god? What if the cybergod was sentient? What if our slashing its roots caused it to thrash madly, destroying the universes as surely as it would have eventually consumed them—only faster?

Crap. Didn't matter; we had to try, if only to prove our true nature as human beings.

I stepped up to the primary control desk, found a newly soldered box sitting atop an open access panel on the plastic console, and glanced at the crew huddled behind me.

"This is it? Just flick the switch to 'ON'?"

The head electrical engineer nodded once.

Hugh added, "You don't have to shut it off. Jenny wrote up a new program for this task. It'll shut down automatically after it's transmitted."

The message was simple. It said, basically, "STOP SENDING TACHYON PROBE-BEAMS INTO THE PAST AND FUTURE. IT SHOULD BE SAFE TO TRANSMIT LONGITUDINALLY, ACROSS LIGHT CONES. IF YOU ARE STILL ALIVE AFTER RECEIVING THIS, THEN IT MUST BE SAFE. PASS ON THIS MESSAGE ONLY IF YOU CAN FOCUS LONGITUDINALLY." We'd included a few more details about the project, about our theory, and so on, in case those alternate Institute teams hadn't thought it up yet. The one-minute message repeated sixty times—Roosevelt's idea.

We should have expected the first thing that happened. We got to listen to the same (or, in a few cases, damn similar) message for the next few hours coming in to our tachyon receiver. Sometimes it targeted our emergency radio, though a few times it arrived via telephone. That puzzled the engineers. Once a local radio DJ called the front secretary to let us know someone was trying to reach us by hijacking his transmitter and would we please have them stop.

Nothing changed noticeably. Only subtle, internal clues revealed that our original order had been restored. Later, we all spoke of a lucidity that had re-

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turned to the world, as if we'd been looking through progressively more and more clouded glass since the shadows started appearing. I began to have trouble recalling $Will_2$'s memories. Hugh's face fell, and I knew he would have to grieve for a lost child he never had. Would he remember the boy's first steps? Would he even remember his name? Had it been a boy or a girl? Roosevelt was the only one who reacted with outright joy at our success. Mostly, I could tell by the lax smiles that my people were simply relieved.

The historian asked, "Did it work?" I looked around the room again, then nodded.

"I knew my being here would pay off," he said, and after some congratulations, left for good

The world became familiar again, so mundanely familiar it seemed alien after having been doubly, triply rich. But we had no concrete evidence of the change until we left the lab and went out into the world. We are all confined to our individual slices of the Universe. And what we make of them.

Over the next few weeks, the entire world took a kind of break. Even the nightly news seemed subdued. I felt the kind of anticlimax one feels after watching an extravagantly hyped, mediocre film. I'm sure the others felt so, too. At four in the afternoon—like everyone else—I drove home, hoping $Will_2$ wouldn't be there already, hoping Laura hadn't broken her promise and let him come home before the weekend. He'd need a few days to process and to fear losing her for good.

I parked the car, unlocked the front door, and entered my living room. Nothing seemed different. Dress shirts blanketed the back of the couch, the air stank of stale food and moldering beer bottles, and dust hung in the light rays like physical objects suspended from the ceiling. Betsy trotted up to me, purring, and rubbed her cheek against my leg.

I sat down in the La-Z-Boy, held my cat against my chest. My eyes burned a bit. I closed them.

I'd lost Laura twice, but in losing her a second time, I had gained myself. I opened my eyes and thought about the future.

A smile touched my lips as I reached for the phone. Now that we'd saved the Universe, it was time for me and Hugh to take that fishing trip.

I'd had enough of death; I was ready to dwell among the living. ■

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Six Moon Dance, Sheri S. Tepper, Avon, $23, 454 pp. (ISBN: 0-380-97479-7).

White Light, William Barton and Michael Capobianco, Avon, $13, 343 pp. (ISBN: 0-380-79515-9).

The Stars Asunder, Debra Doyle and James D. Macdonald, TOR, $ 23.95, 320 pp. (ISBN: 0-312-864108).

Mind Changer, James White, TOR, $22.95, 303 pp. (ISBN: 0-312-86663-1).

Inherit the Earth, Brian Stableford, TOR, $23.95, 320 pp. (ISBN: 0-312-86493-0).

Shiva in Steel, Fred Saberhagen, TOR, $23.95, 318 pp. (ISBN: 0-312-86326-8).

Northern Dreamers, Edo van Belkom, Quarry Press (P. O, Box 1061, Kingston, Ontario K7L 4Y5 Canada), $14.95 US, $19.95 Can, 255 pp. (ISBN: 1-55082-206-3).

The Good Old Stuff: Adventure SF in the Grand Tradition, Gardner Dozois, ed., St. Martin's, $15.95, 435 + xxvi pp. (ISBN: 0-312-19275-4).

An Alien Land, Mike Resnick, Dark Regions Press, $11.95, 213 pp. (ISBN: 1-888993-12-X).

Science in Public: Communication, Culture, and Credibility, Jane Gregory and Steve Miller, Plenum, $29.95, 294 + x pp. (ISBN: 0-306-45860-8).

Sheri S. Tepper can invariably be counted on for absorbing, thoughtful, exciting science fiction. A year ago, I called her—and I'm perfectly willing to repeat it—"a marvelously inventive writer who deserves to sit on the bestseller lists beside any other writer you care to name, in or out of science fiction." Therefore rush right out and buy **Six Moon Dance**, a marvelous consideration of gender roles and compensatory joys, among other things.

On Newholme, relatively few women are born (reportedly because of a virus). Women are thus treasured—dowries are paid to the bride's family and families without girl children can look forward only to poverty—and though they are obliged to play their reproductive role, once they have performed that duty, they have a right to Hunks, "fixed" males who know how to court and charm and pleasure.

Mouche, the only son of a poor farm family, is sold to a school that trains Hunks (properly known as Consorts). There he will be bathed and oiled, trained in dueling and wit and romance, and finally sold to a dutiful wife. Yet while at the school, he discovers hidden passageways in the walls and finds that he can spy upon the ubiquitous "invisible people," the tim-tim, Newholme's natives who perform like brownies the chores of human life.

Invisible? Well, they aren't supposed to be there, for humans are forbidden to settle worlds with their own sentients. But the timmies were not there, not visible, when humans arrived. When they did appear, they had to survive attempts at extermination. Now they are essential, but guilt denies them. They are "the servants men don't see," to paraphrase a certain famous feminist SF title.

That guilt is important. The human worlds are governed by Haraldson's Edicts of Equity, which urge people to choose justice and civility in the compa-

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ny of beauty and joy and are enforced by the Questioner, a powerful android that surveys world after world and, where necessary, takes corrective action. That action can range from a sharp "Tsk-tsk!" to planetary extermination.

And the word is out: The Questioner is coming to Newholme. The high priestesses are very nervous. So are the culture's leading men, for all know that in the name of necessity, their society has shorted justice.

Yet as Mouche and others pursue their tales, complexities emerge. There is also on Newholme a Quaggima, something like a space-going dragon that lays its egg in a world, close to the magma. When the egg hatches, the world trembles and is destroyed.

Newholme is trembling, for its egg awakens whenever the six moons line up just so, as now. The timmies have for millennia danced to keep the egg and its parent quiet, but the human slaughter has weakened their ability to continue. Newholme is threatened. But the Questioner has with her two dancers from Old Earth. If the monsters derived from the first humans to reach Newholme—extremists even among the skinhead male supremacists of the world they left—can be stopped, if understanding can be achieved, then perhaps a world can be saved and joy preserved and extended.

As usual with Tepper, this is not one to miss.

The latest from William Barton and Michael Capobianco is **White Light**, an apocalyptic leap from an Earth ruined by environmental disasters and nuclear war to struggling colony worlds to a superscience interstellar transit system, the Omega Point, and God Himself.

The situation on Earth is so desperate that all those associated with the space program and its fledgling colonies are doing their best to smuggle family members, friends, and even pets to those colonies and safety. Meet Cory Suarez, a fourteen-year-old orphan who has just been bought by the sex-obsessed Wolf O'Malley. Here are Stuart McCray, his mother Thalia Jansky, his stepdad Mark Porringer. Stu's a bright kid with a lot of promise; Mark's an asshole; Thalia's one of Wolf's old flames. And when they all reach the Sagdeev colony, here's Honoria, Cory's Mom and Wolf's live-in housekeeper.

Wolf's a prick, but he saved Cory for Honoria's sake, not that that keeps him from eying her lecherously. Thalia looks at Honoria and gets jealous. Wolf renews activity with Thalia and makes Honoria jealous. Stu yearns for Cory. Mark fumes.

And here's word that an inspection team is on the way from Earth. Hide your illegal immigrants, guys, or they'll be deported home to Earth to die. "Into the ship," says Wolf, and they're off to Beta Pictoris to discover that transit system I mentioned and learn that it is a tiny part of the Topopolitan infrastructure exploited by the BeauHuns the way rats exploit the spaces in the walls of our houses.

And now here come the Topopolitan rat-exterminators. Run again, and discover a galaxy that has been turned into a web of tunnel-like habitats, heavens for humans and other species, hints that here is where all who ever lived in all the alternate worlds of the multiverse shall gather for the end of time, whether as living beings or some sort of simulations, rumors of God, and a seaplane expedition to the Pearly Gates.

What happens to assholes and sex maniacs? They have their chance at redemption. So does everyone, for if one could just peek at all those alternate selves in the alternate worlds and see the different choices one might have made along the way, the different people one might have become, one could learn a great many lessons.

Barton and Capobianco make this point quite well, slipping only at the very end, when some readers, I fear, will feel they turn just a shade too cryptic.

One might also carp that they are not

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concerned with saving the world and its ecosystems, but rather with saving human individuals. That is their call, but such thinking—which is very common—denies important human responsibilities which I wish were more widely recognized.

Debra Doyle and James D. Macdonald are the authors of the popular "Mageworlds" series, which deals with the conflicts between a more or less conventional interstellar civilization and another where "mages" manipulate luck and probability. (You can see samples from the several novels in the series at http://www.sff.net/people/doylemacdonald/books.htp.)

With the latest entry in the series, **The Stars Asunder**, we learn something about how the conflicts all started. Once upon a time, the luck-lines came to be neglected and the galaxy split in two, with the Mage-worlds in touch only with each other and unaware that any others existed at all. Only legend remained of a time before the "sundering." But now comes Garrod syn-Algal sus-Demaizen, final heir to an ancient estate, a Mage of power. He is recruiting a Circle of Mages to tackle the legend and reunite the sundered galaxy. Among his recruits is Arekhon Khreseio sus-Khalgath sus-Peledaen, just finished with his successful training voyage upon his powerful family's starship, *Ribbon-of-Starlight* (I love the names Doyle and Macdonald give their ships). Meanwhile, a movement is stirring to strip the starlord families (such as the Peledaens) of their control of the starways and trade, with *agents provocateurs* encouraging suspicion and fear and the building of armed ships.

Garrod's Circle trains and prepares and finally sends him off to walk the Void in search of a world beyond the gap that marks the sundering. He succeeds, but only at huge price, and when the Mageworlds finally send a ship after him, the two halves of the galaxy do not meet happily. Indeed, it is fair to say that in this meeting, as well as in the paranoia and greed cultivated by the Mageworld rebels, lie all the seeds of future raids and wars that one could wish.

This is an intricate tale, rich in characters and maneuverings. It is thus a little slow to get into, but the momentum builds very nicely, and the reader puts the book down at the end quite ready to buy more in the series.

What more can a publisher ask?

James White's saga of Sector General, that great multispecies hospital that exemplifies the spirit of cooperation that makes civilization—whether confined to one world or spread across the galaxy—possible, has been winding down for awhile. But there is always one more tale to tell of such a place (especially if the author is an Irishman!). **Mind Changer** is that of the irascible and pragmatic chief psychologist, O'Mara, who is being promoted to Administrator of the whole shebang just long enough to find and train his replacement, after which he must retire.

O'Mara's not real happy about being yanked away from his baby this way, but he's had a long and fruitful career at Sector General, and here are highlights, along with an explanation of why he has always lacked the ability to be socially polite and the quite touching revelation of his true love (but watch out for the red herring!). White fans will love this one.

If you've been reading this magazine since July 1995, Brian Stableford's **Inherit the Earth** will seem familiar. The version that appeared here then was "much shorter and substantially different," as the credit says, but it was in essence the same thoughtful and inventive tale.

Inherit the Earth begins with the kidnapping of an old (yet remarkably young) Silas Arnett for supposed crimes against humanity. Yet he was one of

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those who saved humanity from a plague of sterility by developing artificial wombs. That plague arrived at the height of the population crisis, involved genetically engineered viruses, and helped restore sanity to human reproduction, just in time for the development of nanotech IT (internal technology) to start making people immune to disease and injury and—eventually, surely, the big corps promise—death itself.

So what's his crime? Damon Hart is Silas's foster son and the true son of Conrad Helier, the man who was once Silas's chief but has been dead for fifty years. He would like to know, for the kidnappers are sending out notes insisting that Conrad is still alive, somewhere. And he too is guilty.

Of what? Damon's work involves the creation of virtual reality experiences, and when he sees the videotape of Silas's kangaroo trial for creating the sterility viruses, he recognizes it instantly as a fake. Further tapes follow, carrying different claims, and they are faked too. Bodies show up, and though their DNA matches suitable identities, they may also be fakes.

What's going on? Nanotechnology makes reality as malleable as virtual reality. All is appearance. Chaos looms, unless the world's shapers can get together, all on the same team.

Or is chaos a good thing to have roaring around your ears, flooding the system with creative juices? Order? Or freedom? Take your pick, place your bets, and then watch Damon thread his way through the currents of a world on the verge of immortality, where the centenarian-plus old are becoming common and the young are rare and precious, where those who sit atop the social pyramid can play at godhood, and the only pains that remain are emotional.

This may be one of Stableford's best—a pleasure to read, well worth its price, and surely an award candidate.

Fred Saberhagen's Berserkers are of well-deserved and lasting fame. The idea of artificially intelligent, self-reproducing, self-improving war machines turning on and destroying their makers and then waging war against all organic life—including humans—was striking when it was new. Since then it has been used to good effect by other writers, and Saberhagen himself has pounded his own take on it into the ground. He needs a new idea.

The latest Berserker novel, **Shiva in Steel**, makes my point. To the isolated Space Force base at Hyperborea comes hero Harry Silver, just in time to have his ship and his corpus drafted to make up deficits in a doomed mission. It seems that the Berserkers have come up with a tactical genius named Shiva. Scoring success after success against "badlife" humans, Shiva is moving up in the Berserker hierarchy. Soon it will be copied and humanity will be doomed. But the Space Force knows where and when Shiva will be some days hence, and if it can be there then, Shiva will be a cloud of dust.

Alas, the expeditionary force is ambushed on its way to Hyperborea. The surviving commander marshals his few remaining troops and ships, drafts any civilians within reach, and is prepared to sally forth when Shiva comes to Hyperborea for the climactic battle.

Sounds good. But it would have worked better as a lean, trim, fast-paced novelette. Saberhagen's execution of the tale as a novel is sorely lacking. There is so much choppy repetition of nonessentials that the book feels dreadfully padded. It's bloated, swelled up, downright puffy, largely because of all that repetition, you see, and sometimes the repeats even contradict each other. There are also several serious lapses, as when the hero takes a one-hour nap (p. 245) in the middle of the hectic first hour and a half (p. 254) of that climactic battle.

Maybe some of the problems will be edited out before the bound galleys I read are turned into books, but I suggest

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that even if you're a Berserker fan, you'll be happier if you wait to pay the paperback price.

In **Northern Dreamers**, Edo van Belkom presents interviews with twenty-three writers of science fiction, fantasy, and horror who happen to live in Canada. Only one—Robert J. Sawyer, the present president of the Science Fiction and Fantasy Writers of America—was born in Canada. It is apparently a source of some bemusement to van Belkom that the rest—born in the States, England, and France—adopted Canada and turned that relatively small nation into a major bastion of speculative literature.

How major? Let me cherry-pick the names van Belkom covers here: Sawyer, of course, Spider and Jeanne Robinson, W. P. Kinsella, Elisabeth Vonarburg, Andrew Weiner, Michael Coney, Charles de Lint, William Gibson, Phyllis Gotlieb, Dave Duncan, and James Alan Gardner. Some are more "literary" or of more appeal to *Analog* readers than others, but all are major figures in their particular fields.

Van Belkom's biographical introductions to his subjects are necessarily dated—he does not, for instance, mention Sawyer's SFWA presidency—but they are useful background. He does a nice job with the interviews, too, and anyone who wants to know more about Canadian SFFH writers will do very well to buy a copy of this book.

Perhaps it is worth noting how this book demonstrates the Canadian inferiority complex. For one thing, there is more than a hint of apology that more of the writers covered are not home-grown but immigrants. For another, the puff sheet that came with the book proudly proclaims that "talent knows no borders," as if anyone other than parochial egotists had ever thought it did.

And finally, if anyone wishes to reinforce science fiction's own inferiority complex, that same puff sheet calls van Belkom's famous and award-winning subjects "Canada's greatest gift to pop culture," but only after musicians like Neil Young and comedians like Jim Carrey. Alas, the point is surely valid; more people must know who Jim Carrey is than would recognize the names of William Gibson, Phyllis Gotlieb, or Elisabeth Vonarburg, much less the rest.

As Gardner Dozois says in his preface, there is a great deal of astonishingly good SF that was published many years ago and is so neglected today—because publishers pay less attention to marketing their backlists and to reissuing classics—that many younger readers have not even heard it exists. Indeed, they may not even know the names of many of the greatest authors the field has ever known.

This is what Dozois's latest anthology is intended to remedy. **The Good Old Stuff: Adventure SF in the Grand Tradition** includes work by such still familiar names as Poul Anderson, Jack Vance, Ursula K. Le Guin, Gordon R. Dickson, and Roger Zelazny, but how long has it been since anyone has mentioned Cordwainer Smith to you? He's represented here by the marvelous "Mother Hitton's Littul Kittons." A. E. Van Vogt is here with one of his best, "The Rull." Here too are James H. Schmitz, L. Sprague de Camp, C. M. Kornbluth, Leigh Brackett, Brian Aldiss, Murray Leinster, H. Beam Piper, James Tiptree, Jr., and Fritz Leiber, all names to conjure with. This is a book for the memories shelf, one for your local school library, one for a gift to a youngster just discovering SF.

And there will be more. This one's stories are drawn from the period 1948-1971. Dozois promises that *The Good New Stuff*, covering the seventies and eighties, will be out just about the time you see this review.

You can get another excellent dose of good stuff in Mike Resnick's **An Alien Land** collection. None of it's more than

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a decade old, but it's all Resnick, honored by nominations and awards galore, and it's quite enough to convince anyone who needs convincing that Resnick's name will be remembered as fondly as any when the nineties become the "good old days" in their proper turn.

Want proof? See Resnick's caustic view of divinity in "The Pale Thin God." See the poor signing chimp returned to the wild in "Barnaby in Exile." See TR in Africa in "Bully!" (I reviewed the Pulphouse edition in the Mid-December 1990 column). See "Seven Views of Olduvai Gorge." And three more to boot.

You can't lose.

Like your daily paper and *Time* and *Good Housekeeping*, *Analog* is not a science magazine. Like them, its primary mission is something else, but it does include some reports on scientific matters. The reports aren't the same kind, of course, but the audiences aren't either.

And this is just part of the territory subsumed by the term "popular science." If you wish to know more, Jane Gregory's and Steve Miller's **Science in Public: Communication, Culture, and Credibility** is an excellent survey of the issue often called "public understanding of science." They consider the multiple nature of the public, its needs for understanding, the function and role of the media, and even the "culture war" over whether science can make any special claim to truth. They point out that popular science and science journalism often focus on "science in the making," when people seek answers to crisis, argue over risk, and fight out controversy, and when agreed-upon facts can be remarkably scarce. An apt comparison is to city life, where people grant a modicum of trust to strangers on the street until someone they know gets mugged; at that point the trust is withdrawn and every stranger is suspect. So too with scientific and technological issues do people trust the experts until something goes wrong; they don't need to know chemistry or statistics or biology and can proceed quite happily in ignorance. Crisis and risk, however, are the equivalent of the city mugging; they destroy trust and leave people awash in paranoid confusion, which in turn threatens public support for science. And it seems to be that public support that is the chief aim of efforts to enhance public understanding of science.

Should we then try to communicate the facts of science more broadly? Perhaps, though human memory is a sieve for items that don't matter in daily life. Communicate instead the tentativeness of scientific knowledge? Many people don't find that reassuring. Tell people more about the basic scientific attitude of skepticism? That is a threat to the established order and thus not reassuring either.

Yet the public has a right and a need to know about science, and scientists must be open about both the potential and the limitations of their work. Public understanding is essential because it is the public that pays for scientific research, chooses what efforts to encourage or discourage, and decides what results to use.

Recommended for all who are interested in the debates over the place of science and technology in our society. ■

Whenever a man does a thoroughly stupid thing it is always from the noblest of motives.

— Oscar Wilde

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BRASS TACKS

To the Editor:

I agree with Stanley Schmidt (September, 1998) that the principles of science and logic should be taught in all levels of schooling. Many areas of technology could benefit from that level of rigorous thinking, especially the often faulty "science" from the misapplication of statistics that we see associated with the technology that we call medicine. However, I would urge that we also consider teaching the form of logic that is actually used in decision making. Linear logic, the "principles of science," is used to organize data into information. Weighted logic, also sometimes described as fuzzy logic, is what we use to make our decisions. We make decisions in order to attempt to influence the outcome of a process or event that may be external or internal to ourselves. By teaching weighted logic, we examine not only how and why we choose the weighting factors that we choose, we also can explore options for choice that may not immediately be obvious. Decision making involves not just considerations of "benefit to few" as opposed to "benefit to many," but the conceptualization and enumeration of consequences and the possible benefits and/or detriments of those consequences. Isn't that what scientists really desire?

CYNTHIA G. KERN
701 S. FIVE POINTS ROAD
WEST CHESTER, PA 19382

Mr. Schmidt,

I just read your editorial concerning informed decisions (September 1998), and I thought you might be interested to know that the Ohio River has not had a single "safe" rating this year (with respect to coliform bacteria). This is a consequence of horrendously overbuilt communities that allow raw sewage to flow into the Ohio and its tributaries whenever there's too much "storm water" for the processing plants to process. Nevertheless, these same communities consistently reject funding new sewage treatment plants, blindly reciting the mantra of "no new taxes." My state's environmental enforcement can be charitably described as pro-business, so there really seems to be no remedy for the problem.

It was a coincidence that this morning's *Sunday Columbus Dispatch* had an article detailing the sad condition of Ohio's waterways and that you mentioned just that problem in your editorial. The ignorant majority has demonstrated that they see nothing wrong with dumping raw sewage into the water supply—so what's the answer to your question? What is one to do?

FRED HANN
1469 BRADSHIRE DRIVE
COLUMBUS, OH 43220

Dear Dr. Schmidt,

I thought I was in total agreement with your September editorial ("Invisible Enemies, Intelligent Choices"), until the last sentence ("But decisions that affect everybody are everybody's business, and the idea that anybody's opinion is as good as anybody else's just doesn't hold water."). The logical extension of that notion is some form of meri-

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tocracy, and *that* is something I believe is inherently unstable. The aspect of reality that is not captured by such schemes is that relative merit is a dynamic relationship—those who are ignorant or naive can be educated, and those who are the "leading lights" in their respective fields can all too easily become stale and dogmatic. The instability comes about when those in control attempt to extend that control by fixing whatever criteria is used to separate the competent from those judged to be less competent, thus building into society a certain rigidity that inevitably leads to social stresses that are not resolved over time.

Our current sociopolitical arrangements are intended to possess a dynamism that churns people from all parts of society into positions of power. That it is less effective than it should be is one of the great problems of our time. In such a society, what should naturally come about is that people realize that they are unprepared to make the critical decisions that need to be made, and assign representatives (either elected or appointed, as in committees) to deal with the issues. This is one of the strengths of a representative democracy over a pure democracy.

Don't get me wrong, I'm acutely aware of the failings in our current society. I ascribe most of the problems to a grotesquely inadequate educational system, the product of a long period of monopoly control. The only way I could support a meritocracy is if the mechanism of discrimination were controlled by those who would be subjected to the decisions of those deemed "competent." Which is not too far from where we are today.

Keep up the great work. I like the new format.

DAVID LENTZ
CARMEL, INDIANA

I think you read something into the sentence you quote that I didn't intend to put there. "Decisions that affect everybody are everybody's business" implies that everybody should have a part in making them, since everybody has a stake in the outcome. "The idea that anybody's opinion is as good as anybody else's just doesn't hold water" is a simple statement of fact: an opinion that is in close accord with reality is far more useful (and less dangerous) than one that doesn't. That does imply that we'll get better decisions from well-informed people than from ignorant ones. If well-informedness is intrinsic and unchangeable, that might be read as advocating "meritocracy"—but if (as you yourself acknowledge) ignorance is curable, it's more a warning that everyone should become well-informed, so that everyone can contribute rationally to decision-making!

Dr. Schmidt—

Your September editorial touched two of my own hot buttons. With respect to the use of radiation for food sterilization, I long ago concluded that public ignorance made widespread utilization of radiation techniques impossible. Therefore I am holding out for a "Jiffy Home Food Sterilizer." Such a device, about the size of a microwave oven (a radiation appliance that did get accepted), would house a small, interlock-protected radiation source (say Cobalt 60) which could be used by a family to preserve their own food and to treat store-bought food. Of course with all of the regulatory burdens surrounding anything involving radiation, the likelihood of any such device actually becoming available is "Probability Zero."

As for scientific illiteracy, I too used to decry the general lack of scientific education. Finally, I realized that most people prefer certainty to understanding, even if such certainty leads to their deaths. They would rather be wrong and certain than partly (or even mostly) right and not so certain. Unfortunately, scientific inquiry, by its very nature, al-

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ways admits to some uncertainty. Thus, when a scientific disagreement happens to bubble up to the popular press, the general response becomes "If you people can't agree on that, then what good are you anyway?" and all scientific "answers" are discounted. Over time, people do learn, but the process is slow and by no means certain.

DAVE BRIDGER
ST. LOUIS, MO

Dear Stan,

Your editorial about real and perceived dangers was right on target, especially considering that the basis of a democracy is an *informed* electorate.

As a biologist, I've been severely frustrated by every media report I've heard on *E. coli* and intestinal disease. How many seconds does it take to say: "normally a benign bacterium found in the intestine, but this particular strain . . ." Small wonder nobody is informed. There's no one providing any information!

As for irradiation and food sterilization, if gamma rays' effect on the Hulk is a matter of concern, perhaps those psychologists who study children's ability to distinguish between reality and TV should turn their attention to adults. The sad thing is that the woeful lack of knowledge obscures potentially serious concerns. Certainly irradiating food sterilizes it. Certainly it leaves the food nonradioactive. But what it does have is the same effect as leaving food out in the sun for a while: it destroys some of the vitamins. The issue is not whether we'll all turn into Hulks, or, more seriously, get cancer. The issue is should factory farms and slaughterhouses provide conditions adequate to deliver clean meat with its vitamins intact, or do we prefer cheaper food with some vitamins destroyed?

Sometimes I think ignorance is thicker than jam and we might as well give up. Then I remind myself that in the Middle Ages long division was considered Ph.D.-level stuff. We do progress, especially so long as there are people providing the necessary information. Keep up the good work.

DR. MIA MOLVRAY

Dear Dr. Schmidt,

The Alternate View of September 1998 ("Using DNA to Search for Dark Matter") was a fine example of the exotic and yet plausible science that I've come to enjoy in *Analog* (the article on the evolution of universes to maximize production of black holes was another). The article's synthesis of molecular biology and particle physics was especially pleasing to someone who works in the first field but enjoys reading and thinking about the latter.

I did have two quibbles with the article, and a suggestion for a possible improvement to the device. My first quibble is that while the off rate for the biotin-streptavidin interaction is so low as to be unmeasurable under non-denaturing conditions, this does not mean that 100% of the biotin in the solution will bind to the column. One would expect a very small, but non-zero, quantity of biotin-labelled DNA to slip through the column, leading to a small background signal. With the scarcity of WIMP-DNA collisions expected, any background at all would be devastating.

There is an easy solution to this problem, however, which also addresses the problem Mr. Cramer raised about the necessity of destroying the detector for every experiment. Dark matter collisions with the DNA can happen just as well on the streptavidin column as off it—so why not bind all your DNA at the beginning of the experiment, wash off any unbound DNA, and then sit and wait? At your leisure, you can flow more water through the column to collect any strands that may have broken in the interim, and count the fluorophores in solution (or use PCR to look for RNA, or whatever detection method you prefer). This eliminates any background from unbound biotin (since that was washed off at the beginning) and the detector

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will be good for many, many experiments since an insignificant amount of it will actually get used up.

The second problem, which I don't have a solution to, is that the DNA phosphodiester backbone has a very small but non-zero rate of hydrolysis in water. So the rate of DNA molecules falling apart due to water cleavage may be much higher than the rate of DNA molecules being cleaved by exotic particle collisions. Low temperatures and buffered solutions will ameliorate, but not eliminate, this problem.

These quibbles do not in any way detract from the enjoyment I derived from the article (and who knows—have probably already been addressed by Muirhead et. al.), and I look forward to Mr. Cramer's next foray into the frontiers of science.

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P.S. One last *really* minor quibble is that FITC is most efficiently excited by green light, not ultraviolet as suggested in the article.

Dear Dr. Schmidt,

I was much impressed by Daniel Hatch's space mission cost projections. He provides a useful benchmark. After reading a 1982 book by James Bamford entitled *The Puzzle Palace* (an unauthorized history of the National Security Agency), which revealed the vast resources this country has invested over the years in "reading other people's mail" (as Henry Stimson put it), with tangible results such as the non-saving of our Pearl Harbor fleet and our alleged non-anticipation of Indian and Pakistani nuclear bomb tests, I have little doubt that our government could (if it so desired) finance a greatly expanded space program without raising taxes by a single dollar. It would merely have to reallocate some of the billions for which it gives no public accounting. It's not that we don't have the money. It's that we have other things we'd rather do with the money, such as mega-scale snooping, eavesdropping on other nations' (and maybe our own citizens') electronic communications, etc. And what, pray, is our total national investment in speed traps?

Still, many of the costs realistically estimated by Hatch seem excessive. How to cut them down? The first thought that springs to mind is that much of his "throw weight" is dedicated to feeding and coddling what can at best turn into TV talk show personalities. Wouldn't it be a lot cheaper to do the in-space jobs (whatever they may be, and they all sound boring) with machines, and take care of the TV problem with tape recorders or the development of "talking head" homunculi? Surely the latter could easily hold their own against any talk show host . . . unless the inevitable R&D interplay of measure and countermeasure produced an improved breed of host.

OK, I'm kidding—deliberately misunderstanding Hatch. He's considering the jobs in space as just revenue producers, with all the revenue being plowed back into getting people into space. Maybe he needs to be reminded that no revenue-producing activity of mankind has ever yet led to a 100% plow-back of business earnings into anything remotely related to the business. I've already pointed out that if our government (meaning we) wanted to finance more space activity we could do it today—essentially painlessly, unless it hurts to stop doing things we shouldn't.

Finally, there's the matter of advancing technology. I shed no tear for the demise of the Superconducting Supercollider (SSC), because the technology was not ripe for it . . . a fact that was claimed by "scientists" to be correctable by throwing money at the problem. Suppose that, spurred by the intense interest of a small but vocal cadre of "scien-

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tists," we had tried in 1939, at top national priority, to calculate pi to a billion decimal places. A silly thing to do, you say, but just suppose. We could perhaps have done it for the cost of the SSC . . . but aside from the intrinsic silliness, what an added folly it would have been to rush the technology to accomplish fifty years ahead of time what is so readily and cheaply done today.

There is a natural pace of cultural evolution set by the evolution of technology. Hatch didn't speculate about the possibilities of lofting throw weight by new technical means. (Railguns or other electromagnetic launchers come to mind . . . and there are cogent reasons to think that our current knowledge of electromagnetic forces is far from complete.) Perhaps it's still 1939 for both propulsion and launching technologies. If so, this is the era in which we should be investing in research. It's much cheaper to buy knowledge than to pay for ignorance. Always has been. The trouble is, our taxpayers are conditioned to think of "research" as what is done in universities by people with government grants. Actually, research is what was done by the Wright brothers with their own money.

THOMAS E. PHIPPS, JR.

Dear *Analog*,

In reference to the September 1998 article by Dan Hatch, "SpaceBiz 101," there is a serious understatement of current launch costs. From 1971 to date, NASA has spent about $94 billion on the Shuttle which works out to about a billion dollars per flight. In 1998 the eight flights will cost $3.1 billion or about $0.39 billion per mission. The current shuttle cost (based on a payload of 65,000 lb.) is over $7,000/lb. to orbit. However, the shuttle payload has been downrated to 35,000 lb., thus making the orbital payload cost over $14,000/lb. to orbit.

The performance of Venture Star or advanced SSTO would yield a flight cost of about $230 million each per flight because of their low payload capabilities, and high required propellant mass fraction (>92%). These will be lucky to reduce the cost-per-pound by one half compared to the Shuttle. The propellant fraction of the Shuttle is 83.6%. Payload is only 1.43%! Saturn Apollo payload was only 1.6%. By comparison Concorde is only 7.27% and a 747 is about 21%. A passenger car loaded is about 25% payload.

Even at 1963 prices it would be prohibitively expensive to return any Moon metals or materials to the earth, let alone asteroid materials; the Apollo return costs were nearly a half-billion dollars per pound. Consider that the 1963 prices of gold, platinum, or uranium 235 were $4201/lb., $4429/lb., and $28,544/lb. respectively.

Clearly, John Campbell was right: We still don't have an economical space transportation system. Until the conventional rocket (including nuclear) is superseded by something more economical and efficient, all we have is an expensive and very limited space toy.

I am a veteran aerospacer with over twenty years experience in such programs as Apollo, the Shuttle, and the Mars missions. What are Mr. Hatch's qualifications? And where are the references to his costing?

ALFRED J. ZAEHRINGER ■

Nothing is politically right which is morally wrong.

— Thomas Jefferson

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UPCOMING EVENTS Anthony Lewis

12–14 February 1999
BOSKONE 36 (New England Regional SF conference) at Sheraton Tara, Framingham, MA. Guest of Honor—Connie Willis; Official Artist—Stephen Youll; Special Guests—Teddy Harvia, Diana Thayer; Featured Filkers—Ed Stauff and Mary Ellen Wessels. Registration—$35 until 17 January 1999, more at the door. Info—Boskone 36, Box 809, Framingham, MA 01701; (617)625-2311. e-mail—boskone@nesfa.org; URL—www.nesfa.org/boskone

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12–15 February 1999
GALLIFREY 1999 (Dr. Who-oriented conference) at Best Western Airtel Plaza Hotel, Van Nuys, CA. Guests—Elisabeth Sladen, Nicholas Courtney, Gary Russell, Paul Cornell, Eric Hoffman. Registration—$40 until 31 January 1998, $45 at the door. Info—Gallifrey Conventions, PO Box 3021, N. Hollywood, CA 91609; (818)752.3756. e-mail—gallyone@aol.com

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26–28 February 1999
REDEMPTION 99 (British Blakes 7/Babylon 5 conference) at Ashford International Hotel, Ashford, Kent, UK. Guests—Sheelagh Wells, Joe Nazzaro, Gareth Thomas. Registration—£40 in advance, £45 at the door. Info—Judith Proctor, Waveney, 28 Diprose Rd., Corfe Mullen, Wimborne, Dorset BH21 3QY. e-mail—Judith@Blakes-7.demon.co.uk

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4–7 March 1999
WORLD HORROR CONVENTION 1999 at Atlanta Marriott, Atlanta, GA. Guests of Honor—John Shirley, Neil Gaiman, Lisa Snellings. Registration—$75 until 15 February 1999, $100 at the door, $25 supporting. Info—horrorcon@aol.com

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5—7 March 1999
LUNACON '99 (New York City area SF conference) at Rye Town Hilton, Rye Brook, NY. Guest of Honor—Vernor Vinge; Artist Guest of Honor—Bob Eggleton; Fan Guest of Honor—Anthony Lewis. Info—Lunacon '99, PO Box 3566, New York, NY 10008-3566; e-mail—lunacon@lunacon.org

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2–6 September 1999
AUSSIECON THREE (57th World Science Fiction Convention) at World Congress Centre, Melbourne, Australia. Guests of Honour—George Turner (in memoriam), Gregory Benford, Bruce Gillespie. Registration—$155 (A$200), supporting $35 (A$45). [These are the latest posted rates as of the time this column went to press. Rates will go up 1 September 1998 and then again 1 January 1999.] This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Info—Aussiecon Three, GPO Box 1212K, Melbourne VIC 3001, Australia. US Agent—PO Box 266, Prospect Heights, IL 60070-0266. URL—www.aussiecon3.worldcon.org

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4–7 November 1999
WORLD FANTASY CONVENTION/VOYAGES at Rhode Island Convention Center, Westin Hotel, Biltmore Hotel, Providence, RI. e-mail—wfc@mcfi.org; URL—www.world.std.com/~sbarsky/wfc99.html

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